RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1924 [April.

GENERAL REPORT FOR 1923. BY E. H. PASCOE, M.A., SC.D. (CANTAB.), D.SC. (LOND.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

DISPOSITION LIST.

During the period under report the officers of the Department were employed as follows:—

Superintendents.

Mr. E. VREDENBURG	Granted combined leave for one year and four months with effect from the 18th August 1922. Died on the 12th March 1923.
Dr. L. L. FERMOR	Returned from combined leave on the 29th October 1923. In charge of the Central Provinces, Central India and Bombay Party. Left for the field (Central Provinces) on the 20th November 1923.

Dr. G. E. PILGRIM .	Returned from combined leave and resumed duty at Bombay on the 26th November 1923. In charge of the North-West Party; left for the field from Bombay on the 30th November 1923.
Mr. G. H. TIPPER .	Placed in charge of office up to the 25th April 1923. Left for Chitral on the 29th April 1923, and returned from the field on the 17th October 1923. Granted leave on average pay for six months with effect from the 9th November 1923.
Dr. G. de P. COTTER	In charge of the Burma Party.
Dr. J. COGGIN BROWN	Placed in charge of office from the 26th April 1923; continued to act as Palæontologist throughout the year.
Mr H. C. JONES	Confirmed in the grade of Superintendent on the 13th March 1923 *vice* Mr. E. Vredenburg deceased. Returned to headquarters from the field on the 13th April 1923. Granted leave on average pay for six months from the 11th May 1923. Returned and resumed duty on the 12th November 1923. Placed in charge of Bihar and Orissa Party; left for the field on the 5th December 1923.

Assistant Superintendents.

Mr. H. WALKER . .	Returned to headquarters from the field (Central Provinces) on the 3rd May 1923. Appointed Curator of the Geological Museum and Laboratory with effect from the 1st August 1923.

Mr. K. A. K. HALLOWES	Returned to headquarters from the field (Hyderabad) on the 20th April 1923. Granted combined leave for two years and four months with effect from the 21st December 1923.
Dr. A. M. HERON	Returned to headquarters from field work in Rajputana on the 11th May 1923. Continued to officiate as Superintendent throughout the period under report. In charge of the Rajputana Party; left for the field on the 6th November 1923.
Dr. C. S. FOX	Returned and resumed duty on the 20th April 1923 after the termination of his deputation in the office of the High Commissioner for India, London. Examined dam sites at Daddi for the Gokak canal extension project, and on the Panjhan river in connection with the water supply at Manmad Railway station. Returned to headquarters on the 6th May 1923. Left headquarters on the 26th June 1923 to examine the landslips at Murree and the tunnels and cuttings on the Khyber Railway. Returned to headquarters on the 9th July 1923. Attached to the Central Provinces Party; left for the field (Chhindwara) on the 31st October 1923. Appointed to officiate as Superintendent from the 19th September 1922 to the 27th October 1923, and from the 9th November to the 25th November 1923.
Rao Bahadur S. SETHU RAMA RAU.	Returned to headquarters from field work in Burma on the 3rd May 1923. Attached to the Burma party and left for the field on the 6th November 1923.

Rao Bahadur M. VINAYAK RAO.	Returned to headquarters from field work in the Bombay Presidency on the 1st February 1923. Left for Assam on the 5th March 1923 to continue the survey of the Khasi and Jaintia Hills and returned on the 23rd April 1923. Posted in the Madras Presidency to continue the Survey of Salem and Arcot districts and left for the field on the 3rd November 1923.
Mr. H. CROOKSHANK .	At headquarters as Curator up to 31st July 1923. Deputed to investigate the Uhl river Hydro-electric scheme, Mandi State, on the 1st March 1923; returned to headquarters on the 22nd March 1923. Posted in the Madras Presidency to continue the geological mapping along the Madras Coast between Balasore and Coconada. Left for the field on the 1st November 1923.
Capt. C. T. TEYCHENNÉ	Granted an extension of leave without pay up to 26th November 1923. Permitted to retire from the service with an invalid gratuity.
Mr. E. L. G. CLEGG .	Attached to the Burma Party; remained in the Province throughout the period under report.
Mr. D. N. WADIA . .	Returned to headquarters from the field on the 2nd July 1923. Left headquarters on the 14th October 1923, and examined the water resources of Kohat, Bannu, Manzai, and Dardoni (Waziristan). Granted leave on average pay for one month with effect from the 25th November 1923. Attached to North-West Party and returned to the field on the 25th December 1923.

Mr. G. V. HOBSON	Returned to headquarters from the field (Singhbhum) on the 5th May 1923. Left headquarters on the 14th May 1923 to inspect the mica deposits in the South Kanara district (Madras Presidency), and returned to headquarters on the 1st July 1923. Attached to the Central Provinces Party for the inspection of coal mines in the Pench Valley and thereafter for the survey of the Kaira, Godhra and Panchmahal districts in North Bombay and the Indian States in the Rewa Kantha Agency. Left headquarters for the field on the 1st November 1923.
Captain F. W. WALKER	Returned to headquarters for recess on the 18th September 1923. Attached to the Burma Party; left for Rangoon on the 28th October 1923.
Mr. J. A. DUNN	Returned to headquarters from the field (Bihar and Orissa) on the 16th April 1923. Attached to the Bihar and Orissa Party; left for the field on the 31st October 1923.
Mr. A. L. COULSON	Services replaced at the disposal of this Department on the 1st August 1923, after submission of his report to the Railway Board on the Central India Coalfields Railway Survey. Attached to the Rajputana Party; left for the field on the 1st November 1923.
Mr. E. J. BRADSHAW	Appointed Assistant Superintendent, Geological Survey of India, on the 6th January 1923. Posted to Chitral; left for the field on the 29th April 1923. Returned to headquarters on the 17th October 1923. Posted to Assam.

Mr. C. T. BARBER.	Appointed Assistant Superintendent, Geological Survey of India, on the 6th January 1923. Attached to the Burma Party; left for the field on the 11th November 1923.
Mr. E. R. GEE	Appointed Assistant Superintendent, Geological Survey of India, on the 14th December 1923.
Mr. W. D. WEST	Appointed Assistant Superintendent, Geological Survey of India, on the 14th December 1923. Posted to the Central Provinces and Central India Party; left for the field (Chhindwara) 21st December 1923.
Mr. A. K. BANERJI	Appointed Assistant Superintendent, Geological Survey of India, on the 28th December 1923. Placed on special duty in England in connection with the British Empire Exhibition, 1924.

Chemist.

Dr. W. A. K. CHRISTIE .	Returned from combined leave on the 8th January 1923. At headquarters.

Artist.

Mr. K. F. WATKINSON .	At headquarters.

Sub-Assistants.

Babu BANKIM BIHARI GUPTA.	Returned to headquarters for recess from field work in Burma on the 6th September 1923. Granted leave on average pay for one month with effect from the 19th November 1923. Attached to the Burma Party; left for the field on the 28th December 1923.

Babu DURGASHANKAR BHATTACHARJI.	Returned from field work in the Central Provinces on the 6th May 1923. Granted leave on average pay for one month with effect from the 15th September 1923. Attached to the Central Provinces, Central India and Bombay Party; left for the field (Central Provinces) on the 12th November 1923.
Babu BARADA CHARAN GUPTA.	Returned to headquarters from field work in Rajputana on the 2nd May 1923. Attached to the Rajputana Party; left for the field on the 1st November 1923.
Babu HARENDRA MOHAN LAHIRI.	At headquarters.
M. R. Ry. L. A. NARAYANA IYER.	Returned to headquarters from field work in Rajputana on the 7th May 1923. Attached to the Bihar and Orissa Party; left for the field on the 17th November 1923.

Assistant Curator.

Babu PURNA CHANDRA ROY.	At headquarters. Granted leave on average pay for one month from the 1st August 1923.

The cadre of the Department continued to be 6 Superintendents, 22 Assistant Superintendents and one Chemist. Of the 7 vacancies in the grade of Assistant Superintendents existing in 1922, and 2 vacancies in 1923 consequent on the death of Mr. E. Vredenburg and the retirement of Captain C. T. Teychenné, five were filled during the year, leaving at the end of the year four vacancies.

ADMINISTRATIVE CHANGES.

Promotions and appointments.

Mr. H. C. Jones continued to officiate as Superintendent up to the 12th March 1923 and was confirmed in that grade with effect from the 13th March 1923, *vice* Mr. E. Vredenburg deceased.

Dr. A. M. Heron continued to officiate as Superintendent up to the 25th November 1923, *vice* Dr. G. E. Pilgrim on leave, and from the 26th November 1923 *vice* Mr. G. H. Tipper on leave.

Dr. C. S. Fox was appointed to officiate as Superintendent from the 19th September 1922 to 27th October 1923, *vice* Dr. L. L. Fermor on leave, and from the 9th November to the 25th November 1923, *vice* Mr. G. H. Tipper on leave.

Mr. H. Crookshank continued to act as Curator, Geological Museum and Laboratory, till the 31st July 1923 and thereafter Mr. H. Walker from the 1st August 1923.

Mr. D. N. Wadia, Captain F. W. Walker, and Mr. J. A. Dunn have been confirmed in their appointments as Assistant Superintendents.

The following officers joined the Department during the year:—

Mr. E. J. Bradshaw, B.A., B.A.I. (Dub.), on the 6th January 1923.

Mr. C. T. Barber, M.Sc. (Birm.), F.G.S., on the 6th January 1923.

Mr. E. R. Gee, B.A. (Cantab.), on the 14th December 1923.

Mr. W. D. West, B.A. (Cantab.), on the 14th December 1923.

Mr. A. K. Banerji, B.A. (Calcutta), A.R.C.S., on the 28th December 1923.

Babu Abani Kumar Dey, B.Sc. (Calcutta), was appointed Museum Assistant from the 2nd July 1923.

Maung Hla Baw, B.Sc. (Calcutta), Demonstrator in Chemistry in the University of Rangoon, was appointed as Chemical Assistant in the Rangoon Sub-Office of the Geological Survey of India on probation with effect from the forenoon of April 17th, 1923.

Leave.

Mr. G. H. Tipper was granted leave on average pay for six months with effect from the 9th November 1923.

Mr. H. C. Jones was granted leave on average pay for six months with effect from the 11th May 1923.

Mr. K. A. K. Hallowes was granted combined leave for two years and four months with effect from the 21st December 1923.

Captain C. T. Teychenné was granted an extension of leave without pay for three months with effect from the 27th August 1923.

Mr. D. N. Wadia was granted leave on average pay for one month with effect from the 25th November 1923.

Babu Bankim Bihari Gupta was granted leave on average pay for one month with effect from the 19th November 1923.

Babu Durgashankar Bhattacharji was granted leave on average pay for one month with effect from the 15th September 1923.

OBITUARY.

The death of Mr. E. Vredenburg who was a Superintendent in this Department from 1910 to 1923 has been referred to in the Records, Geological Survey of India, Vol. LV part 2.

The death of Sir Henry H. Hayden who was the Director in this Department from 1910 to 1921 has been referred to in the Records, Geological Survey of India, Vol. LV, part 4.

LECTURESHIP.

Mr. H. Crookshank continued as Lecturer on Geology at the Presidency College, Calcutta, until the new session began on the 2nd July 1923 when he was replaced by Mr. H. Walker.

POPULAR LECTURES.

A popular geological lecture on " The Birth of the Ganges " was delivered in the Indian Museum during the Monsoon by Dr. E. H. Pascoe.

LIBRARY.

The additions to the library amounted to 4,295 volumes of which 1,170 were acquired by purchase and 3,125 by presentation and exchange.

PUBLICATIONS.

The following publications were issued during the year under report :—

Memoirs, Vol. XLIV, part 2.
,, ,, XLVII ,, 2.
,, ,, XLIX ,, 1.
Records, ,, LIII ,, 4.
,, ,, LIV, parts 3 & 4.
,, ,, LV ,, 1 & 3.
Palæontologia Indica, New Series, Vol. VII, Memoir No. 2.
,, ,, ,, ,, VIII ,, ,, 1.
Bibliography of Indian Geology, part 3.

MUSEUM AND LABORATORY.

Staff.

Mr. H. Crookshank was Curator of the Geological Museum and Laboratory from the beginning of the year to the end of July. On the 1st of August

Mr. H. Walker assumed the duties of Curator. Babu Purna Chandra Roy retained the Assistant Curatorship throughout the year. The two posts of Museum Assistant were vacant at the beginning of the year and remained so until Babu Abani Kumar Dey was appointed to one of them on the 2nd of July.

Chemist.

Dr. W. A. K. Christie, Chemist, has been engaged chiefly with the routine work of the laboratory. He has also investigated an interesting group of zeolites from the Deccan Trap, some of which he has described in a paper now in the Press.

Determinative work and Analyses.

The number of specimens referred to the Curator for examination and report was 237. Assays and analyses were made of 44 specimens. The corresponding figures for 1922 were 497 and 102 respectively. The specimens which were analysed were largely coals and lignites but in addition there were oil-shales, hornblende and zeolites. Many determinations of the calorific values of coals, by means of the bomb calorimeter, were made.

Donations to Museums, etc.

During the year under review presentations of geological specimens were made to the following institutions :—

(1) The Benares Hindu University.
(2) The Bethune College, Calcutta.
(3) The Chief Engineer, Great Indian Peninsula Railway.
(4) The Government Laboratory, London.
(5) The Hyderabad Museum, Deccan.
(6) The Jaipur Museum, Rajputana.
(7) The *Muséum National d' Histoire naturelle*, Paris.
(8) The University College of Science, Calcutta.
(9) The University of Geneva, Switzerland.
(10) The University Institute of Giessen, Germany.
(11) The Urdu Normal School, Amraoti.
(12) The Zilla School, Bhagalpur.

Additions to the Collections.

A very large amount of mineral material has been presented to the Department. This material has been incorporated in the exhibit which is about to be sent to the British Empire Exhibition, and to which fuller reference is made elsewhere.

These specimens will be included, ultimately, in the Collections of the Department. In addition, donations of the following specimens have been added to the collections :—

(1) Apatite rock from the Vizagapatam district. Presented by Mr. V. S. S. Iyer.
(2) Bricks of various kinds. Presented by Messrs. J. H. Sankey and Sons, Ltd.
(3) Chrome brick. Presented by Messrs. Austin and Young.
(4) Chromite. Presented by the Baluchistan Chromite Co., Ltd.
(5) Crucible made from sillimanite. Presented by Messrs. Geo. Holloway, Ltd., London.
(6) Kaolin and sand for glass-making. Presented by the Rajmahal Quartz, Sand and Kaolin Co.
(7) Ochre. Presented by the Forest Research Institute, Dehra Dun.
(8) Quartz epimorphous after chabazite. Presented by F. L. G. Simpson, Esq.
(9) Sodalite with calcite, apatite and graphite. Presented by Mr. Wright of the Burma Ruby Mines, Ltd.
(10) Tungstite on wolfram from Hermyingyi, Tavoy. Presented by W. Harman, Esq.

Calcutta Exhibition, 1923.

A small collection of important Indian economic minerals was shown at the Calcutta Exhibition, 1923. Unfortunately, the choicest specimens of our collections had already been set aside and packed for the British Empire Exhibition. On this account and by reason of the short notice given it was not possible to do justice to Indian Mineralogy, Petrology, Palæontology and Stratigraphy at this Exhibition.

A start has been made with a geological museum in Rangoon and temporary quarters have been obtained in the office of the Conservator of Forests (Sittang Circle), 46A, Dalhousie Street. In all, the museum contains 13 show cases containing specimens of 180 minerals, 140 rocks and 242 fossils. The collection consists for the most part of a donation from the Geological Survey of India, Calcutta, and although at present somewhat scanty, is fairly representative as regards general minerals and rocks and Burma fossils. It is hoped that, as the Museum becomes known and is made use of by the numerous geologists who pass through Rangoon, it will be possible to expand the exhibits into a really good collection of Burma minerals, rocks and fossils. As the museum progresses the display of geological wall maps will be materially increased and besides general maps of the various parts of the Indian Empire, will include the detailed work carried out in Burma by officers of the Geological Survey.

Laboratory.

A small chemical laboratory has now been equipped in the Rangoon Office and Maung Hla Baw, B.Sc. (Calcutta), appointed as Chemical Assistant. During 1923, 29 specimens have been examined and reported on; of these 3 were quantitatively analysed.

BRITISH EMPIRE EXHIBITION.

Early in the year orders were received from the Government of India that the Geological Survey of India should prepare an all-India mineral exhibit for display at the British Empire Exhibition, to be held in London in 1924. Dr. J. Coggin Brown was entrusted with the task of arranging, cataloguing and packing this collection and carried out these duties with his usual thoroughness and foresight. The work was completed before the end of December and the 109 cases containing the specimens despatched to London, where they will be displayed and cared for by Mr. A. K. Banerji, Assistant Superintendent, who has been placed on deputation for the occasion.

The bulk of the collection, which has been drawn from the materials stored in the Geological Survey Office and Museum, in addition to 58 geological maps, sections and photographs and 144 volumes of publications, comprises 289 rock specimens and 787 minerals, collected in the past by the officers of the Department, in the course of their routine duties. Many of these, though invaluable from a scientific standpoint are not however, sufficient for a popular display. It was decided therefore to enlist the assistance of mining firms and others interested in the mineral industry throughout India, and to request them to present large and showy specimens, or typical products of their enterprise, for inclusion in the all-India collection. The generosity with which this has been responded to is evident from the list of donors given below, and in very few instances was a refusal met with. The new specimens so obtained supplement the nucleus prepared in this office, and make it thoroughly representative, while, at the same time they will prove a valuable addition to the Imperial collection of minerals on their return to India.

The collection is grouped as follows :—

Class I.—Rocks.

Class II.—Minerals—(i) Ores, (ii) Other minerals of economic importance, (iii) Minerals of scientific interest.

Class III.—(i) Geological maps and sections, (ii) Photographs, (iii) Publications.

The collection of rocks includes typical representatives of the Archæan formations of the Peninsula, the Himalayan granites, the Charnockite series, the Elæolite-syenites and Augite-syenites, the Pegmatites and their associated minerals, the Peridotites and related rocks, the Deccan Trap, Recent volcanic rocks from regions adjoining India, typical Gondwana rocks from the Giridih coalfield and striated and facetted boulders from the Salt Range.

The collection of ores includes natural compounds of aluminium, antimony, arsenic, chromium, copper, gold, iron, lead, silver, zinc, manganese, molybdenum, tin, titanium, tungsten and zirconium.

The collection of minerals of economic importance includes abrasive minerals, (corundum and garnet), asbestos, barytes, borax, calcium salts, coal, graphite, magnesium compounds, mica, monazite, ochres-oil, shale, ornamental stones, petroleum and its products, phosphates, potassium salts, rare-earth minerals, refractories, salt, slate, steatite, strontium salts and sulphur.

A list of the special donations received for the all-India Mineral exhibit is given below :—

1. Gondwana Rocks belonging to the Talchir and Barakar series from the Giridih coalfield. Presented by H. G. Lancaster, Esq., Chief Mining Engineer, East Indian Railway Co., Ltd.
2. Chromite. Presented by the Baluchistan Chrome Co., Ltd.
3. Copper Ores from the Mosaboni Mine and a specimen of metallic copper smelted by the ancients. Presented by the Cordova Copper Co., Ltd.
4. Copper Ore from the Bawdwin Mine. Presented by the Burma Corporation, Ltd.
5. Iron Ores and raw materials used in the manufacture of iron; samples of various grades of pig iron; various castings including pipes, axle-boxes, chairs, brake-blocks, railway sleepers and an electric-light standard. Presented by the Bengal Iron Co., Ltd.

6. Iron Ores from the Bababudan Hills; limestones used as flux; various grades of charcoal; pig iron; wood-tar, calcium acetate and methyl alcohol, manufactured by the Mysore Wood Distillation and Iron Works. Presented by the Geological Survey of Mysore.
7. High-grade lead-silver ore and zinc-lead ore from the Bawdwin Mine. Presented by the Burma Corporation, Ltd.
8. Twenty-six specimens of manganese ores from the Sooklee, Miragpur and Selwa Mines. Presented by the Central Indian Mining Co., Ltd.
9. Cassiterite and wolfram from the Hermyingyi, Kanbauk and Widnes mines, Tavoy district, Burma. Presented by Burma Finance and Mining, Ltd., the Kanbauk (Burma) Wolfram Mines, Ltd., and the High Speed Steel Alloys, Ltd.
10. A series of specimens illustrating the processes involved in the production of metallic tungsten from wolfram. Presented by the High Speed Steel Alloys, Ltd. of Widnes, England.
11. Ilmenite sand from Travancore. Presented by Messrs. Hopkin and Williams, Ltd., Colachel.
12. Zircon sand from Travancore. Presented by Messrs. Hopkin and Williams, Ltd., Colachel.
13. Garnet sand from Travancore. Presented by Messrs. Hopkin and Williams, Ltd., Colachel.
14. Crude asbestos and prepared material made from it. Presented by the Feudatory Chief of Seraikela, Bihar and Orissa.
15. Barytes—"massive lump," "picked lump" and "crushed." Presented by the Indian Minerals Co., Betamcherla, Karnul district, Madras.
16. Borax, refined from crude Tibetan "Tincal". Presented by B. Sheopratap, Esq., Calcutta.
17. Coal from various seams of the Raniganj coalfield. Presented by the Bengal Coal Co., Ltd., Messrs. Andrew Yule & Co., Messrs. Burn & Co., Messrs. Martin & Co. and Messrs. Balmer, Lawrie & Co.
18. Coal from various seams of the Jharia coalfield. Presented by Messrs. Martin & Co., Messrs. Andrew Yule & Co., the East India Coal Co., Messrs. Anderson Wright & Co. and Messrs. Kilburn & Co.

19. Coal from various seams of the Giridih coalfield. Presented by the East Indian Railway Co., Ltd.
20. Coal from the Singareni coalfield. Presented by the Singareni Collieries Co., Ltd.
21. Coal from the Pench Valley coalfield, Central Provinces. Presented by Messrs. Shaw Wallace & Co.
22. Coal from the Umaria coalfield. Presented by His Highness the Maharaja of Rewa.
23. Coal from the Makum coalfield. Presented by the Assam Railways and Trading Co., Ltd.
24. Hard coke, coal-tar and sulphate of ammonia, from the Loyabad By-product plant, Jharia. Presented by the Barakar Coal Co., Ltd.
25. Graphite from Travancore. Presented by Messrs. Hopkin & Williams, Colachel.
26. Magnesite—" crude lump," " lightly calcined lump," " lightly calcined ground and sintered." Presented by the Magnesite Syndicate, Ltd., Suramangalam, Madras.
27. Magnesium Chloride, Magnesium Sulphate, refined salt, and brine, from Kharaghoda, Bombay. Presented by the Pioneer Magnesia Works.
28. Many specimens of light and dark coloured phlogopite mica from Travancore. Presented by Messrs. Hopkin and Williams, Ltd., Colachel.
29. A very large collection of the various sizes and grades of prepared Nellore Muscovite mica. Presented by the following donors through the Director of Industries, Madras: M. R. Ry. Venkatappa Naidu of Kadapah, The Krishna Mining Co., The Tellabodu Co., M. R. Ry. Vellattur Venkatah Naidu, M. R. Ry. Vissa Lakshminarasayya Pantalu, M. R. Ry. Subbaraghava Iyer, K. C. Narasinha Chariar, M. R. Ry. Sundararama Pillay, M. R. Ry. Kandamur Venkatasubbaya, M. R. Ry. Yellisiri Subba Reddy, the Sankara Mining Syndicate, M. R. Ry. Veeraghava Reddy, the Kalichedu Mining Co., and M. R. Ry. Pitchiah and M. R. Ry. G. Lakshinarayudu.
30. Monazite sand from Travancore. Presented by Messrs. Hopkin and Williams, Ltd., Colachel,

31. Crude and levigated yellow ochre and golden-yellow paint made therefrom. Presented by Messrs. Turner, Morrison & Co., Calcutta.
32. Red oxide of iron and red ochre from the Bellary district, Madras; yellow ochre from the Karnul district, Madras. Presented by the Indian Minerals Co., Betamcherla.
33. Four cubes of Mirzapur sandstone. Presented by Messrs. George Henderson & Co., Ltd., Calcutta.
34. Crude petroleum and ten specimens of various oils and wax distilled therefrom, from the Digboi Oilfield, Assam. Presented by the Assam Oil Co., Ltd.
35. Two specimens of crude petroleum from the Badarpur oilfield, Assam. Presented by the Burmah Oil Co., Ltd.
36. Crude petroleum and seventeen specimens of various oils made therefrom, from the Khaur oilfield, Punjab. Presented by the Attock Oil Co., Ltd.
37. A large collection of phosphatic nodules, from the Trichinopoly district, Madras. Presented by Messrs. Staines & Co., Coimbatore.
38. Apatite-magnetite rock from the Singhbhum district, Bihar and Orissa. Presented by Messrs. Shaw Wallace & Co., Calcutta.
39. Ground apatite rock. Presented by the Indian Phosphates Syndicate, Calcutta.
40. Potash salts from the Salt Range. Presented by the Northern India Salt Revenue Department.
41. Fireclay and fire bricks; quartzite and silica bricks. Presented by the Kumardhubi Fire Clay & Silica Brick Co., Ltd.
42. Large cubes of white and pink Rock-salt. Presented by the Northern India Salt Revenue Department.
43. A large collection of slates and slate utensils of various kinds, from the Kharakpur Hills, Bihar and Orissa. Presented by Messrs. Ambler & Co., Calcutta.
44. Roofing slates of various sizes, from the Kangra Valley Punjab. Presented by the Kangra Valley Slate Co., Ltd.
45. Kaolin, from the Rajmahal Hills. Presented by the Calcutta Potteries, Ltd.

46. Glass sand, from the Rajmahal Hills. Presented by the Director of Industries, Bengal.
47. Agate pebbles and Carnelian beads. Presented by the Director of Industries, Bombay.
48. Topaz crystals and plates; aquamarine, from Sakangyi; Katha district, Burma. Presented by A. H. Morgan, Esq., Chief Engineer, Burma Ruby Mines, Ltd.

PALÆONTOLOGY.

During the year Dr. G. de P. Cotter's memoir entitled "The Lamellibranchiata of the Eocene of Burma" was published in the *Palæontologia Indica*, as volume VII, Memoir No. 2, of the New Series. The specimens themselves were collected between the years 1910 and 1911 by Dr. Cotter, the late Mr. H. S. Bion and Rao Bahadur Sethu Rama Rau; they comprise twenty species from the Yaw stage, of which fourteen are new, and five species from the Pondaung Sandstone, two of which are new to Science.

Dr. Erich Spengler's memoir entitled "Contributions to the Palæontology of Assam, has also appeared as volume VIII, Memoir No. 1 of the New Series of the *Palæontologia Indica.* The greater part of the material described was derived from an old collection, which was already known in the year 1869, when H. B. Medlicott's "Geological Sketch of the Shillong Plateau in North-Eastern Bengal," was published (*Mem., Geol. Surv. Ind.*, vol. VII, pp. 151-207). The remainder was collected some years ago by Mr. P. N. Bose and by Lieutenant-Colonel Godwin Austen, F.R.S. Of the ninety-four forms of upper Cretaceous fossils examined by Dr. Spengler, the state of preservation of twenty-five did not admit of specific determination, while ten species were new. Of the remainder, fifty per cent. proved to be identical with species from the South Indian Ariyalur group, including *Stigmatopygus elatus*, *Ostræa* (*Alectryonia*) *ungulata*, *Nerita devaricata*, *Lyria crassicostata* and *Baculites vagina.* Three of the new species are also very closely related to species from the Ariyalur group. Sixty-one per cent. of the specifically determinable forms belong to the Upper Senonian.

Dr. Spengler considers that his analysis of the relationship between the Upper Senonian faunas of S. India (Ariyalur), Assam and Baluchistan "shows clearly that the fauna of Assam occupies a medium position between that of South India and that of Baluchistan." If, however, we take into account the difference in size of the three known faunas, the intermediate position of the Assam fauna between the other two does not appear so clearly established. Assam may be in a numerically intermediate position but the intermediacy seems to be of so slight a nature as to be of no reliable significance. All that seems justifiable is the conclusion that the faunas of Assam and S. India are closely similar and evidently belong to the same life province. The question is important as bearing on the existence or non-existence of a sea-connection between Assam and Baluchistan *viâ* the Indo-Gangetic trough in Cretaceous times. Amongst the supposed upper Cretaceous fossils of the Khasi Hills, Dr. Spengler found three echinoids of Tertiary age, one of which proved to be a new species.

Dr. Cowper Reed has continued his investigation of the upper Carboniferous fauna of Chitral and the Pamirs, and of the Carboniferous, Permian and Triassic fossils collected in Yunnan some years ago by Dr. Coggin Brown. The plates illustrating the former memoir are completed while those accompanying the latter are in an advanced condition. Both memoirs should be issued in the *Palæontologia Indica* in the coming year.

The very numerous text figures which illustrate Mr. Forster Cooper's "*Anthracotheriidæ* of the Dera Bugti deposits in Baluchistan," have been finished.

Owing to the extreme pressure of work in the Drawing office and the loss of time caused by illness during a particularly unhealthy year amongst the staff, it was found impossible to proceed with the preparation of the plates which form part of the late Mr. E. W. Vredenburg's memoir on "Mollusca from the Post-Eocene Tertiary formations of North-West India," and of his "Review of the genus *Gisortia.*" Work on these materials is, however, now in progress. For the same reasons the preparation of the plates for the late Captain R. W. Palmer's paper on "An Incomplete Skull of *Dinotherium*, with notes on Indian forms," was also delayed.

The following papers of palæontological interest appeared in the *Records* during the year :—

(1) "Indian Tertiary Gastropoda, IV; *Olividæ, Harpidæ, Marginellidæ, Volutidæ,* and *Mitridæ*" by the late E. W. Vredenburg.

(2) " Indian Tertiary Gastropoda, V; *Fusidæ, Turbinellidæ, Chrysodomidæ, Strepturidæ, Buccinidæ, Nassidæ, Columbellidæ,* with short diagnoses of new species; by the late E. W. Vredenburg.
(3) " On the structure of the Cuticle in *Glossopteris angustifolia* Brongn." ; by Prof. B. Sahni.
(4) " Revision of some Fossil Balanomorph Barnacles from India and the East Indian Archipelago"; by T. H. Withers.
(5) " Oligocene Echinoidea collected by Rao Bahadur S. Sethu Rama Rau in Burma" ; by the late E. W. Vredenburg.

Other works in the course of publication, or accepted for publication, include :—

(1) " On the Blake collection of Ammonites from Kachh" ; by Dr. L. F. Spath.
(2) " Fossil Molluscs from the Oil Measures of the Dawna Hills" ; by Dr. N. Annandale.
(3) " Notes on an Armoured Dinosaur from the Lameta Beds of Jubbulpore" ; by Dr. Matley.
(4) " On some Fossil forms of *Placuna*" ; by the late E. W. Vredenburg.
(9) " On the Phylogeny of some *Turbinellidæ*" ; by the late E. W. Vredenburg.
(6) " A Provisional List of Fossils collected in Yunnan by Dr. J. Coggin Brown" ; by Dr. Cowper Reed.
(7) " On a Calcareous Alga belonging to the *Triploporelleæ* (*Dasycladaceæ*) from the Tertiary of India" ; by John Walton.
(8) " The *Perissodactyla* of the Eocene of Burma"; by Dr. G. E. Pilgrim.
(9) " On a Fossil Ampullarid from Poonch, Kashmir"; by Dr. B. Prashad.

The fourth part of Mr. T. D. LaTouche's Bibliography of Indian Geology, which consists of a Palæontological Index, is in final proof form and should be issued early in 1924.

Dr. J. Coggin Brown continued to act as Palæontologist throughout the year, and during the period has been assisted by Sub-Assistant Harendra Mohan Lahiri. A considerable amount of labour was involved in the removal of the type collections of the Department to a more convenient situation on the first floor of the office and in the checking and redisposal of large accumulations of fossils, removed from the collections in the Museum for purposes of study, over a period of years.

Routine determinative work from extra-departmental sources, accomplished during the year, included the examination of fossil collections—some of them of large size—from the Nummulitic rocks of the North-West Frontier Province, from the Tertiary deposits of Assam, Burma and Kathiawar and from the Quetta Museum.

A large collection of fossils from the Burmese Tertiary rocks was brought together for the branch office of the Geological Survey of India in Rangoon, and a somewhat smaller one was presented to the Burmah Oil Co., Ltd., in return for the numerous donations received from the Company in the past. Several casts of Siwalik Vertebrates were presented to the *Muséum Nätional d' Histoire naturelle*, Paris.

Amongst the Indian specimens added to the collections, in addition to those brought in by officers of the Geological Survey of India, the following deserve especial mention :—

(1) A large collection of Jurassic ammonites from Kachh, presented by Mr. J. H. Smith through the Bombay Natural History Society.

(2) Tertiary fossils from Dwarka, Kathiawar, presented by Mr. F. L. G. Simpson.

(3) Plant impressions and fish-spines from the Kamapyin coal-field, Mergui district, Burma, presented by Burma Finance and Mining, Ltd.

(4) A small collection of Tertiary fossils from Bagmara, Assam, presented by the Burmah Oil Co., Ltd.

(5) A large oyster from Swallow Lane, Calcutta, presented by Mr. H. de C. Baillardie.

(6) A collection of Cretaceous ammonites from the Trichinopoly district, Madras, presented by Messrs. Staines & Co., Coimbatore.

The Jurassic ammonites from Kachh received through the generosity of Mr. J. H. Smith of Bhuj, represent the results of several years' collecting, and form the largest donation of its kind received by the Department for a number of years. Arrangements have been made for the specimens to be described by Dr. L. F.

Spath of the British Museum, to whom has also been entrusted the task of revising the types of the Kachh ammonites described in 1873-76 by Waagen (*Pal. Indica*, Ser. IX, Vol. I).

The occurrence in Swallow Lane, Calcutta, of large oysters of which a specimen was presented by Mr. H. de C. Baillardie, is not without interest. The species has been determined as *Ostræa gryphoides* Schlotheim. In 1904, an oyster band containing similar remains was found 5 feet below surface level in Clive Street, only 150 yards in a straight line from Swallow Lane. The occurrence was described by the late Mr. E. W. Vredenburg in *Records*, volume XXI, pages 174-176 (1904). It is referred to in the General Report for the period April 1903 to December 1904 (*Records*, vol. XXXII, p. 136) where Mr. Vredenburg's conclusion that the bed was *in situ* was naturally held to prove oscillations of the relative level of land and sea in recent geological times. At a later date (*Records*, vol. XLII, pp. 1-15 (1912) Messrs. Bullen Newton and Smith, as the result of an examination of other specimens found below the level of Clive Street, threw grave doubts on the theory that the oyster bed had a natural marine origin. Dr. Coggin Brown has discussed the whole matter in the light of the present find in a paper entitled "On the Occurrence of *Ostræa gryphoides* Schlotheim, in Calcutta" to be published in the Journal of the Asiatic Society of Bengal, and in it concludes that "the last discovery, in the absence of further evidence, has left the problematical origin of the Clive Street oyster bed precisely where it was before."

Since this paper was written further evidence has been forthcoming in the shape of new deep excavations in Swallow Lane. A detailed examination of these, before they were filled in, revealed the presence of cinders and broken pottery amongst the oyster shells some 5 or 6 feet below road level, so that it can now be definitely asserted that the shells were deposited on their present site by human agency in comparatively recent times. The older theory that the deposits immediately underlying Calcutta are of fresh-water or estuarine origin without any traces of marine sediments, must, therefore, again be upheld.

In September last, during the progress of widening operations on the main line of the East Indian Railway a short distance beyond Asansol, several large fossil trees of Gondwana age were unearthed. Unfortunately, most of them were destroyed before information reached this Department, but one has been saved and has been promised to the Geological Survey of India by the East Indian Railway Company, who have further kindly consented to transport it to Calcutta. The locality was examined by Mr. H. Crookshank.

Mud Volcano.

Arakan Coast, Burma.

A new island was formed off the Arakan coast about 8½ miles south of Tiger Point on West Baronga Island (lat. 19° 30′; long. 93° 2′ 15″) and was first discovered on the 14th November 1923. It was examined eleven days later by the Port Officer, Akyab, who has been kind enough to supply further details. The island was reported to consist of "black mud which being in lumps gives the idea of rocks." It is described as flat-topped with perpendicular sides, the latter being evidently the result of marine denudation, and was expected to disappear at an early date leaving the usual dangerous shoal. On the 25th November its height was 30 feet and length 200 feet. The island is the result of a "mud volcano," the rock-like lumps and débris being partly composed of fragments of the stratified rocks through which the eruption has made its way. It is on the same line of strike as the large well-known "mud volcano" in Cheduba Island. There is of course nothing truly volcanic about such phenomena which are caused by pressure of petroleum gas below the surface.

ECONOMIC ENQUIRIES.

Apatite.

Apatite was found in the Seraikela State and adjoining portions of the Singhbhum district by Mr. J. A. Dunn, who considers that there may be sufficient to repay careful prospecting.

Asbestos.

Chitral.

Poor asbestos in narrow veins was found by Mr. Tipper in the basic rocks in the stream running west from the glacier above the camping ground of Deh Shal on the road from the Shah Janali Pass in Chitral.

Building Materials.

Mr. Hallowes reports that the biotite-granite-gneiss of many localities in Hyderabad would furnish sound and durable stone suitable for the construction of houses or docks, and, when polished, ornamental material for pillars. Cubes of the stone from the nineteen chief quarries of the area were collected for tests. These shewed a specific gravity of 2·61-2·68, and a crushing strength varying from 14·40 to 23·04 tons per square inch. The absorption of each fresh unaltered stone after soaking for twenty-four hours in water is practically nil. In weathered samples the specific gravity and the crushing strength were found to be low, while the absorption of the stone to water became appreciable.

Coal.

Bhusawal; Bombay.

The attempt to prove the existence or non-existence of coalfields beneath the Deccan Trap in western India was continued during the year under review. The boring of the Great Indian Peninsula Railway Company between 1,165 and 1,217 feet passed through nothing but fine-grained traps with green earth. (See General Reports for 1920 and 1921).

Central Provinces.

During late December 1922 and early January 1923 Mr. H. Walker was occupied in sampling the seams of coal worked at the Sasti and Ghugus collieries of the Ballarpur Colliery Company in the Central Provinces.

Pench Valley: Central Provinces.

At the request of the Central Provinces Government Mr. G. V. Hobson was instructed to carry out an inspection of various collieries in the Pench Valley coalfield, chiefly with the object of deciding whether it would be possible, by relaxing certain regulations in the coal leases, to put Central Provinces' coal on a more secure footing and enable it to compete more successfully with the Bengal and Bihar and Orissa products and more especially with imported coal from Natal. Mr. Hobson has submitted a report on the various areas with remarks on the general coal situation in the Pench Valley.

Coal Washing.

In view of the profound importance to the steel industry of India of adequate supplies of coking coal, the Government of India have during the past year, given financial support to some experiments on the cleaning of the various Indian coals by the Froth Flotation process. These experiments have been carried out on the Geological Survey premises by Mr. W. Randall under the authority of Messrs. Villiers, Limited. During the year, some 70 samples, from most of the coalfields of India, have been tested in this way. Some of the coals have responded to the treatment and the successful application of the process seems to be a matter of finance. There are large areas of sub-bituminous coals, such as those of the Central Provinces, which appear to be entirely non-coking and which cannot therefore be cleaned to yield coking products. On the other hand, the second-class coals of Jharia and Bokaro have been found amenable to cleaning. Mr. Randall reports that many of those coals, which are of no commercial value as coking coals since they yield weak coke of high ash content, have been treated to yield a clean product which can be made into coke of excellent quality. It now remains to be proved whether the process can be employed remuneratively on a commercial scale. As the reserves of high-grade coal become depleted and prices rise, it seems justifiable to anticipate that the Froth Flotation process will become more and more commercially feasible. Mr. Randall considers that there are Indian coals which could today be profitably cleaned. It is hoped to publish shortly a preliminary report upon the results of these experiments.

Copper.

Chitral.

A small deposit of azurite (derived from copper pyrite) and galena was observed by Mr. Tipper to occur at the village of Chapari in Chitral. A similar deposit in a very inaccessible place is to be seen about 4 miles up the valley. Incrustations of copper carbonates occur in the basic rocks on the road from the Shah Janali Pass just above the first hamlet in the Upper Turikho Valley.

Rajputana. (*See under* Pyrite).

Engineering Questions and Allied Enquiries.

Railway alignment: Bihar and Orissa.

To assist in the selection of the most suitable alignment of the proposed connective line between the Katni and Daltonganj areas in Bihar and Orissa, Mr. A. L. Coulson was deputed to accompany the Railway Survey Party, and has submitted a detailed report. He was concerned chiefly in examining the coalfields which will be opened up by the construction of either of two alternative railway lines, the northern of which joins Katni (B. N. R., E. I. R., G. I. P. R.) with Hutar which lies to the south of Daltonganj (E. I. R.), whilst the southern line connects Anuppur (B. N. R.—Bilaspur-Katni Branch Line) with Hutar. It is proposed to connect Hutar with Daltonganj on the north by an extension of the existing Daltonganj line, and with Hesla on the east by a line which has already been surveyed by the East Indian Railway.

From a mineral standpoint the southern line (Line A) undoubtedly possesses prior claims for construction over the northern line (Line B). Line B merely affects the Singrauli, Tatapani and Hutar coalfields, whereas Line A would open up the eastern part of the Sohagpur and the Jhagrakhand, Sanhat, Kurasia, Jhilmili, Bisrampur and Hutar coalfields. The coals of the Singrauli and Tatapani fields cannot compare in quality with those of the Jhagrakhand and Kurasia areas alone so far as evidence went. Assisting the claims of Line B, we have, it is true, the corundum formation at Pipra in Singrauli, and the iron ores of the same district, but the latter seem rather a doubtful asset; in any case these advantages cannot counteract the overwhelming claims which Line A possesses through its coalfields enumerated above.

Dam-site; Manmad, Bombay.

Dr. C. S. Fox on his return from deputation with the High Commissioner for India in London was asked to investigate a water-supply dam in the Panjhan River at Manmad on the Great Indian Peninsula Railway, and, on behalf of the Bombay Public Works Department, an irrigation dam near Belgaum. The Manmad scheme was considered faulty from a geological standpoint owing to the presence of a concealed filled-up valley in the line of the projected dam. This would necessitate a very long dam to hold up the water and prevent it from percolating through the porous materials in the old valley.

Dam-site; Belgaum, Bombay.

The Belgaum scheme concerned the important question of irrigation in the Deccan and involved three possible dam-sites near Daddi, two of which needed detailed attention. Dr. Fox finally advised in favour of the longer dam, its alignment having two recognizable advantages over the other. The strata would dip upstream at the longer dam where also there is strong rock on to which the spillway could discharge without fear of undermining. In both cases a certain amount of leakage was anticipated through the jointed rock of the north bank. This leakage would, however, find its way back into the Ghatprabha river and thus rejoin the regulated flow which was being discharged to meet the canal draw-off from the Gokak reservoir. Dr. Fox was able to point out to the Irrigation Engineer the defects and advantages of the two kinds of rock, basalt and quartzite, which were at his disposal for building the dam. This reservoir will be an important work, as the existing reservoir near Gokak station would not supply water to the new canals which are to be constructed on the dry watershed of the Krishna (Kistna) to the east.

Dam-site; Nankwe, Yamethin, Burma.

Dr. G. de P. Cotter in January 1923 visited the proposed site of the Nankwe dam in the Yamethin district, (about 12 miles east-north-east of Yamethin). The rocks in which the proposed reservoir and dam would lie are a series of slates, hornstones, mudstones, quartzites and sandstones, evidently referrable to the Chaung Magyi series described by LaTouche. The rocks of the site were deeply weathered, and Dr. Cotter advised that the trial pits along the site should be deepened so as to reach if possible fresh unweathered rock.

Dam-site; Ingon, Kyaukse district, Burma.

Another dam-site at Ingon village in the Myittha township of the Kyaukse district was examined by Dr. Cotter in January 1923. The formations on which the site is aligned are andesite, limestone, travertine, and river alluvium of the Panlaung River. The presence of pot-holes in the travertine, which may be the openings of subterranean channels caused some alarm, but it was concluded that further investigation was necessary, and that, if they proved to be channel openings, it would be possible to close them to a large extent by cementing the openings with concrete.

Dam-site: Kyatkon, Myingyan district, Burma.

Captain F. W. Walker was deputed to examine a dam-site at Kyatkon village in the Myingyan district (lat. 20° 48½′; long. 95° 15′). The site lay over Irrawaddy Sandstone, tuff, volcanic conglomerates and alluvium; it was decided that the alluvium is too porous, and the site therefore unsuitable.

Land-slip: Murree, Punjab.

In June soon after the arrival of the Monsoon Dr. Fox received orders by telegram to proceed to Murree to examine a land-slip which had just taken place and which was evidently still unstable. After investigating the area it was possible to indicate to the military authorities concerned the limits of the unstable area and to mark those places where movement was likely to be greatest. There appeared to be no cause for alarm, but it seemed likely that certain buildings would suffer by being distorted or fractured by the unequal movement of the sinking ground. Thorough remedial measures were seen to be far too elaborate for immediate adoption, but the plan outlined had in view the gradual pinning of those portions which allowed of human control at a reasonable outlay. The slip area as a whole will jam itself in time and if meanwhile the "active" areas are avoided for building sites there is not likely to be much further damage, once the smaller protective works are fixed.

Uhl River Hydro-electric scheme: Punjab.

As an alternative to the Sutlej scheme a project for the development of hydro-electric power in the Mandi State of the Punjab has been considered. At the request for geological advice by Colonel Battye, the Engineer in charge, Mr. H. Crookshank was instructed to visit the area and submit a report. The proposal is to take advantage of the fact that the floor of the Uhl valley is at a much higher elevation than the parallel bed of the Rana river to the west, both streams flowing generally S. S. E. into the Beas. In consequence of this, it is possible to obtain a powerful head of water by deflecting the waters of the Uhl into the Rana through a tunnel driven across the intervening watershed. Particular attention has been devoted to a scheme between Ghog in the Uhl valley and Shanan on a tributary of the Rana; additional energy is available by continuing the scheme down to the Nairi *nala* near Kun. An alternative scheme down the Uhl valley from near Ghagatyan to Urla is also being kept in mind, but the Ghog-Shanan project is receiving more attention.

The beds are not far from the vertical, most of them dipping very steeply to the east, and belong to two series, ancient unfossiliferous Krol slates and quartzites forming the main mass of the watershed and the valley of the Uhl river, and partially consolidated beds of soft marl, sandstone and conglomerate of Tertiary—probably Siwalik—age forming the Rana valley and lower slopes of the divide. The difference in height between the two valleys is due largely to the greater erosion of the softer beds in the Rana valley.

Dr. Fox who reported on the old Sutlej scheme has supervised Mr. Crookshank's report and is of opinion that the hill-slopes are structurally safe as regards serious landslips owing to the steepness of the inclination of the strata. Water conduits or reservoirs on the younger softer porous rocks would have to be lined or puddled with clay to prevent leakage. The area lies within a seismic region of known instability and the risk of earthquake must be faced, as indeed it must in any part of the Punjab; it does not necessarily follow that any engineering structure will be seriously injured by such an earthquake shock. To reduce the risk Dr. Fox advises that all structures should be built of small or moderate-sized blocks of stone or better still of brick, that tunnels should not be driven across well-marked fault planes, that dams and weirs should be founded on unfissured rock, and that power-houses and pipe-lines where possible should be built or secured on solid rocks, alluvial slopes exceeding 15° being avoided.

Although the plane between the Krol beds and the Siwaliks has not been definitely proved to be a plane along which movement has recently taken place, it is a plane of weakness to be avoided where possible in tunnel sections. The proposed reservoir on spur "4240" will be liable to small cracks and will have to be watched; it should be of brick. The extension scheme mentioned above involves no great risks from a geological point of view, but the Ghog tunnel whose intake it is proposed to cover with nearly 160 feet of water by means of a dam at Tarwan, should be lined with masonry in order to resist the scour of water under pressure.

The alternative scheme mentioned above consists in driving a tunnel from the bend of the Uhl River, W. S. W. of Ghagatyan, through the slates and quartzites, across their strike, to emerge near Rajan south-east of Urla. This tunnel would not cross the junction between the Krol and Siwalik beds; otherwise the geological considerations are very similar to those of the main scheme.

Excellent building materials in the form of granite, quartzite, slate, lime-stone, and sand are available on the spot but good brick-clays unfortunately do not appear to be so conspicuous.

Gems.

Ruby Mines ; Katha district, Burma.

Dr. Cotter visited the Ruby Mines of Mogok and Katha in the Katha district, in order to collect specimens of the waste sands from the separating pans and sorting sheds. Samples were collected of all the waste from the washing plants ; these have been carefully examined by the Chemical Assistant, Maung Hla Baw, but no trace of any previously unknown minerals was discovered nor was anything of commercial value found in the waste.

Gold.

Seraikela State : Bihar and Orissa.

Gold-washing is occasionally practised on the sides of the hills between Samram (lat. 22° 44′ 2″ ; long. 86° 4′) and Basulitocha, in Seraikela State.

Graphite.

Rajputana.

Midway between Rajore and Dandia Dr. Heron reports that a small incline has been driven to a distance of about 15 feet into a specially graphitic band in a limestone which here forms the base of the Delhi system. The graphite is, however, too contaminated with clayey matter to be of economic utility.

Two irregular beds of graphitic material averaging a foot in thickness and separated by a yellow quartz vein occur at Bar Railway Station. Three small pits have been sunk on the bed, shewing it to have a strike extension of 100 feet. One of the pits is over 40 feet deep and passes out of the graphitic deposit. The graphite has so far been found too impure for sale.

Half-a-mile south-west of Ajitgarh are six small pits, about 10 feet deep, sunk in a band of graphitic or carbonaceous schist just above the base of the Delhis. This material likewise is too impure to be of any commercial value. Two small pits have been sunk for the same purpose at Cheriabarh, one mile north of Jawaja.

About a mile south of Lotiana, along a line immediately below the south-east side of the summit, quite extensive workings of graphite exist. The bed is a graphitic or carbonaceous mica-schist, dipping north-west into the hill at 75°-85°, with a maximum thickness of 10 feet including 1½ feet of grey quartzite in the middle. This maximum is near the south-western end of the ridge, and the bed thins out rapidly towards that end and more gradually towards the north-eastern end. The pits, 20 in number, are in the form of square inclines, and are in many cases double, the medial quartzite band forming a partition. They are from 20 to 30 feet deep and are said to be connected laterally by drives along the graphite bed. The roof consists of micaceous quartzite and is very insecure. One hundred and fifty coolies are said to have been employed at one time in extracting and conveying the graphite, but it is difficult to understand why so much work was done on such poor material.

Iron and Steel.

The Indian Tariff Board having requested the assistance of the Geological Survey in their consideration of the question of protection for the Steel industry in this country, Dr. C. S. Fox was requested to draw up a note on the raw materials available for that industry in India. Extracts from his note are to be published as an appendix to the Tariff Board's report.

Kaolin.

Seraikela State: Bihar and Orissa.

The working of china-clay is a flourishing industry in Seraikela, one of the Feudatory States of Bihar and Orissa. This material is derived mostly from the granite and is found along its margins at several localities, among which are :—Chapra, Mundakati, Bharatpur, Gengemri, south of Samram, Ghagi, Koludih, Rangamatia, Jaspur and Raghunathpur.

Lead.

Chitral.

In addition to the Chapari locality (*see* Copper, Chitral, p. 24) galena also occurs at Gazan high up on the left bank of the stream draining from the Tui Pass in Chitral.

Magnetite.

Rajputana.

A piece of magnetite weighing 5 pounds was brought to Dr. Heron from a place half-a-mile north of Kalade (survey sheet 168). It is derived from a quartz vein, probably a segregation in the coarse magnetite-bearing granite which characterises that locality.

Mica.

In October, 1922, Mr. G. V. Hobson was deputed to the Nellore district, Madras Presidency, to inspect the mica mines with a view to ascertaining whether there had been any improvement in the methods of mining due to the action of the Mica Inspection staff, and whether the latter had justified their existence. The conclusion arrived at was that the establishment of this Mica Inspection staff had not resulted in any improvement in mining methods. Their chief duties appeared to be in connection with the collection of royalties, and as revenue officers they may be considered to have justified their existence.

Nellore ; Madras.

In January, 1923, Mr. Hobson returned to the Kodarma mica area in the Hazaribagh district, Bihar and Orissa, to complete the inspection of the mines in this area commenced last season. On the completion of this inspection, the views formerly expressed were confirmed, the necessity of mine plans and sections being more apparent. It was further concluded that the system of contract-working is undesirable and encourages mining on unsound lines. Its discontinuance would do much to prevent unmethodical grabbing which is causing waste, and would assist any scheme to reduce mica thieving which is ruining the industry.

Kodarma ; Bihar and Orissa.

In May, 1923, Mr. G. V. Hobson visited Mangalore in the South Kanara district to examine an occurrence of mica reported from the Uppinangadi and Upidi taluks of this district. The majority of the points from which mica had been reported were inspected, but the breaking of the Monsoon curtailed the investigation. In none of the cases reported had mica *in situ* been found ; this was true with regard to all cases visited, and from enquiry the same appeared to be true of those not visited, the mica found being surface mica accumulated in the soil. This surface mica was neither abundant, nor of good size. Much of the mica seen was badly buckled, cross-grained and otherwise flawed, and none of it would cut more than " No. 1 " in size.

Kanara district ; Madras.

Ochre.

It occurred to the writer some time ago that the powdery hæmatite which exists in enormous quantities in Bihar and Orissa and which is at present not being utilised for the manufacture of pig iron, might have a considerable potential value as a paint-material or ochre. Attempts on a laboratory scale to convert it from its present dark steel-grey colour to that of red ochre by intensive weathering with moisture, air and carbon dioxide, have not, so far, been successful. If such a conversion were possible, the result would be of far greater value than any smeltable iron ore. This is a line of research which offers great possibilities.

Pyrite.

Kharwa : Rajputana.

Dr. Heron inspected a mine from which iron pyrites is extracted at a small village named Goari (Guaria, 26° 12′ ; 74° 30′), 1½ miles east of Kharwa in Rajputana. The deposit was found during the digging of a well, which has been widened and deepened to form a shaft 75 feet deep. The ore occurs in one of the pegmatite veins which happens to cut across the shaft about half-way down, the country rock being well-bedded flaggy tremolite schists. The vein "dips" at a low variable angle towards the north and its underlying portion has been brecciated by a folding movement and the breccia cemented by the sulphides pyrite and chalcopyrite and an undetermined mineral ; chalcopyrite is much subordinate to the iron sulphide. About 2 feet of the vein is sulphide-bearing. Two levels, 35 feet and 10 feet long, have been driven but pass out of the vein which "dips" below them. The mine is equipped with two oil-engines, a smaller one lying outside ; these were used for working pumps which have since been removed, and are now employed for lighting the shaft by electricity. Dr. Heron remarks that such brecciation of pegmatite is unusual in the district and is not likely to be more than a local crushing of limited horizontal extent.

Road Metal.

Kyweinzu ; Henzada district, Burma.

Rao Bahadur Sethu Rama Rau was requested to examine the Kyweinzu quarries near Mezaligon in the Henzada district. The rocks exposed are hard fine-grained sandstones suitable for road-metal, of which there is an abundant supply.

Mr. B. B. Gupta was instructed to examine the Shinmataung Hill Range north of Pakokku town in order to discover road-metal. A very suitable hill of olivine basalt, already previously mapped by Mr. K. A. K. Hallowes, was found about 14 miles north of Pakokku, north-east of the village of Kyansein. The basalt of this hill, it is expected, will make an excellent road-metal.

Shinmataung: Pakokku district, Burma.

Large quantities of good road-metal are available in the country west of Hyderabad in the form of epidiorite which traverses the gneiss in numerous dykes and appears to be tough and durable.

Hyderabad ; Deccan.

Salt.

At the request of the Government of Bombay an officer was deputed to investigate the anticipated exhaustion of the brine wells in the Little Rann of Kachh, in view of the falling off of the supply of brine near the edge of the Rann. Rao Bahadur Vinayak Rao was deputed for this purpose.

Rann of Kachh.

Salt is being obtained at Kharaghoda close to the south-eastern border of the Little Rann, the brine being pumped from shallow wells. Mr. Vinayak Rao advised a line of borings at regular intervals across the Rann from Kuda in the Dharangadhra State and from Tikar a few miles further to the west. No borings were put down during the field season 1922-23, but with the generous assistance of the Dharangadhra Durbar a line of shallow wells was dug north-east of the Kuda salt-field at intervals of approximately one mile. The depths varied from 4 to 9 feet, the material passed through consisting of three or four layers of stiff bluish and black clay containing crystals of selenite, overlying a brine-bearing gritty sand. Analyses of the brine by the Department of Industries show that the brine becomes more concentrated towards the middle of the Rann, and that the percentage of chloride remains much the same in the constituents of the brine from all the wells. Deeper systematically arranged borings are necessary to prove the presence of deeper brine sands or deposits of salt.

There is little doubt that the brine in the sand has been imprisoned by the overlying clay. The latter contains some cerithiids and a *Cyrena*—probably *Cyrena impressa* Deshayes—, while in the sand were found fragments of *Avicula*, *Corbula* and *Nassa*. It would thus appear that estuarine have succeeded marine conditions in Recent times in the Little Rann.

Sagaing and Shwebo : Burma.

Captain F. W. Walker visited the salt workings of the Sagaing and Shwebo districts. His results have been noted in the last annual report.

Tin.

Mergui district, Burma.

The alluvial flats of the Khe Chaung (Survey sheet $96\frac{M}{2}$) carry tin ore, and have recently been worked for tin.

Steatite.

Seraikela : Bihar and Orissa.

Steatite or Talc occurs associated with the Dharwar rocks in Seraikela State, and was at one time worked west of Bara Kadel in the southern end of the State. Here the mineral occurred *in situ* as the altered product of an ultra-basic igneous rock. According to Mr. J. A. Dunn more thorough prospecting might bring to light additional high-grade deposits.

Water.

Chalisgaon : Bombay.

In reply to a request from the Great Indian Peninsula Railway Rao Bahadur M. Vinayak Rao was deputed to report on the water-supply at Chalisgaon Railway station at the junction of the Ar and Tittur rivers. The supply from a well in the bed of the Tittur and from others close by having proved inadequate, a dam had been constructed across the Ar river at Warthan, some eight miles south of Chalisgaon, and water led from the resultant reservoir by a pipe to the Railway station. This arrangement proved a failure owing to leakage through the dam. Mr. Vinayak Rao found it difficult to prescribe a remedy for the leakage but has suggested the addition of powdered dry clay. With regard to the prospects of additional wells, there are two possible sources of water. The rocks of the neighbourhood consist of a vesicular trap overlain by a dolerite, and are concealed south and east of Chalisgaon by Older Alluvium. Water has been tapped in the junction between the vesicular trap and the dolerite, and also from the Older Alluvium. Judging from the yield of a private well near the railway station the supply from the former source is very limited; the owner of this well is, with the assistance of the Agricultural Department, putting down a boring, the result of which is awaited with interest. From the Older Alluvium, which in places reaches a thickness of nearly 100 feet, there are more hopeful prospects. Wells east of Chalisgaon market and south of the Tittur appear to yield a fairly good supply.

Water Supply of Mandalay.

In November, 1922, Dr. Cotter examined the tube-wells of Mandalay and reported favourably on the prospects of obtaining sufficient supplies of drinking water for Mandalay town.

Hyderabad : Deccan.

Mr. Hallowes considers that the water-supply in parts of Hyderabad could be supplemented by sinking wide deep wells to reach the porous calcified gneiss or one or more of the inter-Trappean horizons.

Water : Landi Kotal, N.-W. Frontier.

While in the North-West Dr. Fox proceeded to Peshawar and the Khyber Pass to see the tunnels on the railway and to discuss with the Engineer-in-Chief the possibilities of augmenting the water-supplies for the Fort at Landi Kotal. It was agreed that increased rainfall is probably the only really effectual remedy, but that there is a possibility of tapping underground water on the south side of the valley in the limestone by a moderately deep boring. A boring, 400 feet deep, in the lower valley of Landi Khana would, in Dr. Fox's opinion, almost certainly tap good supplies of rather "hard" water; this might necessitate softening for use in locomotives, and would, moreover, have to be pumped up to Landi Kotal from a position which could possibly be rushed by a determined enemy.

N.-W. Frontier.

A request from the Military Works Department for an examination of the water-supply of the four military posts of Kohat, Bannu, Dardoni and Manzai was met by the deputation of Mr. D. N. Wadia, who visited these areas towards the end of the year, and has submitted a report.

GEOLOGICAL SURVEYS.

Khasi Hills : Assam.

A short remnant of the field-season was spent by Rao Bahadur Vinayak Rao in a continuation of Captain Palmer's work in the Shillong Plateau of Assam. In the western part of the Khasi Hills bordering the plains, Cretaceous, Nummulitic and Tipam rocks were identified, and the resemblance of the latter to the Siwaliks noted. Mr. Vinayak Rao considers that the beds west of Bagali Barar, extending as far as Moheshkala on the Garo Hills border, are probably of Dagshai or Kasauli age.

Singhbhum : Bihar and Orissa.

During the field-season of 1922-23, the Bihar and Orissa Party consisted of Mr. H. Cecil Jones (in charge), Messrs. G. V. Hobson, J. A. Dunn and Sub-Assistant Durgashankar Bhattacharji.

Mr. Jones continued the geological survey of the Kolhan Government Estate in Singhbhum, to which reference has been made in preceding General Reports. His work was interrupted by inspections made by him of the boring operations of the Tata Iron and Steel Co., on some of the iron deposits held by them near Mohudi, east of Jamda, and also by visits of inspection to Mr. J. A. Dunn who was working east of Chaibassa in Singhbhum, and to Mr. Bhattacharji who was working west of Nagpur in the Central Provinces. Mr. Jones accompanied the Director in an inspection of some of the iron ore deposits of the Kolhan Government Estate, and of Keonjhar State. Towards the end of the camp-season Mr. G. V. Hobson accompanied Mr. Jones for a few weeks, in order to gain experience in geological mapping.

The geology of the area worked by Mr. Jones is complicated, and the work consequently somewhat slow. The breccia conglomerate noted by Mr. Jones during his preliminary survey of the iron ore bodies in field-season 1918-19 has now been located by him in several other parts of the area. At present the work done on these different occurrences has not been connected up, but where it has been possible to work out the sequence, a certain similarity has been made out. The breccia conglomerate is a very striking rock, but is somewhat variable in character, and usually consists of angular to sub-angular fragments, mainly of banded hæmatite quartzite and cherty silica in a siliceous cement, but in some cases, as at Jiling Buru near Gua, the rock is made up of angular to sub-angular fragments of laminated hæmatite cemented together by ferruginous material. This latter variety forms a valuable ore of iron.

Near Tholkabad on the western side of the main iron-ore range the breccia conglomerate is very thick and is well exposed, whilst at Sagad Buru near Bukna on the east of the same range, there is a good section showing the same breccia conglomerate but as a much thinner bed. The sequence of rocks at these two points is very similar and is as follows :—

Tholkabad.	*Sagad Buru.*
Quartzite.	White fine-grained quartzite with a thin band of conglomerate near the top.
Reddish purple shale.	Reddish shale.
White fine-grained quartzite.	Breccia conglomerate.
Ferruginous sandy shale.	
Breccia conglomerate.	

The breccia conglomerate overlies a considerable thickness of light-coloured shales at Sagad Buru. A very similar sequence of rocks, but reversed in order, was noted near Balibah, some five miles north of Tholkabad. Here the sequence was as follows :—

Breccia conglomerate
Brown sandy shale.
White fine-grained quartzite.
Reddish purple shale.
Grey quartzite.

The breccia conglomerate and the white quartzite here and at Tholkabad, appear to be the same bed. This possibly indicates an overfold about this point, but the area between Balibah and Tholkabad has not yet been worked out, and the elucidation of this possible overfold will have to remain for another camp-season.

Some time was spent on some of the basic trap intrusions of the area. Owing to the large amount of silicification and weathering that has taken place in some of these rocks the mapping of boundaries is difficult. The trap very often weathers into a shale-like rock which is indistinguishable from the ordinary shale of the area.

Mr. J. A. Dunn continued his work on Survey sheets $73\frac{F}{15}$, $\frac{F}{14}$, $\frac{F}{13}$, $\frac{J}{2}$ and $\frac{J}{1}$, of the Singhbhum district and Seraikela State. The granitic area, as reported last year, is cut up by a remarkable and regular series of reticulating dolerite dykes which frequently attain large dimensions, reaching to half-a-mile in width and cropping out for 8 or 10 miles along the surface of the ground. North of Gobindpur (sheet $73\frac{J}{2}$) is a large circular outcrop of dolerite which may be a relic of the boss from which many of the dykes emanated. The Iron Ore series continues to north of Seraikela but within a short distance gives place to schists, quartzites, phyllites and epidiorites of undoubted Dharwar facies. Both groups dip northwards and appear to have the same strike, the Iron Ore series beneath the Dharwars. The nature of the junction was not made out but the boundary was placed provisionally at a peculiarly sheared conglomerate in which the pebbles were found to be squeezed and drawn out in a remarkable manner. It is presumed that the sequence has been inverted by an overfold.

Mr. G. V. Hobson accompanied Mr. Jones in the Singhbhum district for about a fortnight for instructional purposes in field mapping just north of Tholkabad, after which he continued the mapping northwards towards Ponga. The whole area is covered with shales with the exception of a small patch of conglomerate just north-west of Kulaiburu and of one or two isolated patches of igneous rock in the streams.

Burma.

During the field-season 1922-23, the Burma Party consisted of Dr. G. de P. Cotter (in charge), Rao Bahadur S. Sethu Rama Rau, Mr. E. L. G. Clegg, Captain F. W. Walker, and Mr. Bankim Bihari Gupta, Sub-Assistant. In November and December, Dr. Cotter visited the Man river section in the Minbu district with Mr. Clegg and Captain Walker, and the section between Pakokku and Gangaw with Captain Walker, for instructional purposes.

Mergui district, Burma.

Mr. S. R. Rau continued the geological survey of the Mergui district, his work covering portions of sheets $95\frac{L}{16}$, $96\frac{I}{9}$, $\frac{I}{10}$, $\frac{I}{13}$, $\frac{I}{14}$ and $96\frac{M}{2}$. The geological map of Mergui has thus been carried southwards to the latitude of 11° 30.′ The area mapped consists of the mainland and the islands close to the coast. By far the greater proportion of the country mapped is covered by rocks of the Mergui series. These consist of dark grey argillites, indurated grits and agglomerates, dipping at high angles with a prevalent strike of from 15° to 20°. On the islands and on the coast phyllites, quartzites and indurated shales characterise the Mergui series in which are several small intrusions of biotite granite and of tourmaline pegmatite. A larger boss of granite is exposed at the source of the Khe Chaung in sheet $96\frac{M}{2}$. In this neighbourhood the alluvial flats of the Khe Chaung carry tin ore, and have recently been worked for tin. In Medaw Island (sheet $96\frac{I}{10}$) a sill of fine-grained olivine basalt is found in the Mergui series. Mr. Rau considers that this basalt is of the same age as the porphyries discovered in a former season by Dr. Heron in some of the outer islands (see *Records Geol. Surv. Ind.*, LIV, p. 52). A cap of laterite covers the central portion of the basalt outcrop.

Minbu and Thayetmyo districts.

Mr. E. L. G. Clegg continued the geological survey of the Minbu and Thayetmyo districts, over portions of sheets $84\frac{L}{3}$, $84\frac{L}{6}$, $84\frac{L}{7}$, $84\frac{L}{12}$, $85\frac{I}{9}$, $85\frac{I}{10}$, $85\frac{I}{13}$, $85\frac{I}{14}$ and $85\frac{I}{15}$. An interesting synclinal basin was mapped near Sidoktaya in sheet $84\frac{L}{6}$, which is faulted down on the west of the great axial strike-fault of the Nwamataung range. This brings Pegu beds into juxtaposition with Pondaung sandstones near Handauk village. Further south-west of the same strike-fault in sheet $84\frac{L}{12}$, there is a small cuvette or synclinal basin near Sabagyidan, where lower Pegus (Padaung Clay horizon) are faulted against Pondaung sandstones. The age of the Pegus is well fixed by the presence of *Lepidocyclina elephantina* Tourn, *Lepidocyclina* sp. and *Heterostegina* sp., which is the same association found in the main outcrop of the Padaung Clay to the east. In sheet $89\frac{I}{9}$, a third cuvette west of the Nwamataung strike-fault exposes lower Pegu beds (Shwezetaw Sandstones) with a well-marked fossiliferous limestone band beneath, containing the same fauna as is found in the Kyet-u-bok band (see *Records Geol. Surv. Ind.*, XLI, p. 226). The Kyet-u-bok band is characterised, both here and in its main outcrop, by *Orthophragmina omphalus* Fritsch, while molluscan species of the Yaw stage are also found, such as *Volutoconus birmanicus* Dalton, *Tellina* (*Arcopagia*), *Tazuocusis* Cotter and *Cardium thetkegyinense* Cotter. The fossil species and the lithological characters of the limestone make it quite clear that the band surrounding this cuvette is the same as that of Kyet-u-bok. An examination of these two cuvettes, and the fixture of their ages by means of their fossil contents, lead to the very interesting conclusion that the Pegu series and Kyet-u-bok band in these areas strongly overlap the Pondaung Sandstones.

The Kyet-u-bok band has been traced from Kyet-u-bok as far south as latitude 19° 45′. Southwards it dies out, but small discontinuous bands are met with. Mr. Clegg regards the Kyet-u-bok fauna as typically Yaw stage, and has taken the band as the upper limit of the Eocene. Southwards in sheets $85\frac{I}{14}$ and $\frac{I}{15}$, there is no well-marked band or horizon whereby to separate the

Pegu series from the Eocene, which is here conformable. The boundary mapped has been fixed mainly on palæontological evidence. Lithologically the upper Eocene may be described as shales grading down into more arenaceous beds, without sharp transitions. A few lenticular seams of coal are found in the shales. The lower Pegus are sandy in sheet 85 $\frac{I}{14}$, but to the south of this sheet, these sandy beds are underlain by shales in the Tiyo-Pungyi valley. The lower Pegu shales in this area may be distinguished from the Eocene by the absence of coal seams, and by their different appearance. A collection of fossils from the Eocene includes two new species of *Ampullina*, and various specimens of *Orthophragmina* which have not yet been worked out.

In this area the Pegu series contained no new points of interest. The divisions adopted in north Minbu and Pakokku of the Pegu and Eocene series could not be maintained in this southern area, owing to the rapid changes in the character and facies of the beds, which were no longer sharply marked zones of alternating sandstones and shales. In mapping the Eocene, the Yaw stage and the Pondaung sandstone have been grouped as one unit, while the lower Eocene has been divided into a group consisting of the Tabyin Clays, Tilin Sandstones and Laungshe Shales, and another group equivalent to the basal Paunggyi conglomerates. This is due to the disappearance of the Tilin Sandstones as a continuous horizon. Certain sandstones occur at the horizon of the Tilins near Sidoktaya in sheet 84 $\frac{L}{3}$, but they are discontinuous and fade into shales along their strike. Similarly south of sheet 84 $\frac{L}{12}$, the Padaung Clay horizon of the Pegu series is no longer mappable, since the Shwezetaw stage and the middle Pegus above develop argillaceous beds, through which the Padaung Clay boundaries are obliterated. In sheets 84 $\frac{L}{3}$ and 84 $\frac{L}{7}$, the Eocene-Axial boundary was mapped for a distance of about 20 miles. Wherever the boundary was examined basal Eocene conglomerates were found to be present. Mr. Clegg is of the opinion that the boundary is unconformable. Amygdaloidal trachitic lavas were found at several points along the boundary between Hpa-aing and Sidoktaya.

Pakokku and Lower Chindwin districts, Burma.

Captain F. W. Walker was engaged in mapping parts of the Pakokku and Lower Chindwin districts, in sheets 84 $\frac{K}{5}$, $\frac{J}{8}$ and $\frac{J}{12}$. The formations mapped were Pegu series (undivided), Yaw stage, Pondaung Sandstones, Tabyin Clays, Tilin Sandstones, and Laungshe Shales. The outstanding structural features are the Kyaw syncline and the Pondaung anticline which roughly follow a N.—S. direction through $\frac{K}{5}$ and $\frac{J}{8}$. The Kyaw syncline occupies the valley between the mountain ranges of the Pondaung and the Ponyadaung, both lofty hills, the former attaining a height of 4,000 and the latter of 3,000 feet. The centre of the Kyaw syncline is occupied by Yaw Shales, and to the north in sheet $\frac{J}{8}$ still higher beds—basal Pegus—are exposed in a small basin.

The Pondaung Range shows anticlinal structure, the crest of the anticline running parallel to and about 1 mile east of the watershed. The crest shows exposures of Tabyin Clays in which are several seepages of oil and gas. Thin seams of coal (a few inches thick) are characteristic of the Tabyin Clays in this area. On the borders of sheet 84 $\frac{J}{8}$ and $\frac{J}{12}$ another syncline occurs, pitching gently to the north from the southern margin of sheet $\frac{J}{8}$ near the village of Mayin. This last syncline is on the same axis as the syncline which has been mapped north of Pauk, and the two synclines are to be regarded as the result of the same folding movement. Both in sheets 84 $\frac{J}{8}$ and 84 $\frac{K}{5}$ a considerable number of transverse faults were mapped. Besides these a few strike-faults have also been detected. Captain Walker has made collections of fossils from the Tilin Sandstones, which he is at present studying. Besides these a few mammalian teeth were collected from the Pondaungs, including *Anthracohyus rubricae* Pilg. & Cotter, and *Metamynodon sp.* In the Yaw stage a good collection of previously known species was made.

Gangaw sub-division; Pakokku, Burma.

Sub-Assistant Bankim Bihari Gupta was engaged in mapping sheets 84 $\frac{K}{1}$ and 84 $\frac{J}{4}$, part of the Gangaw sub-division of the Pakokku district. The valley of the Maw and Myittha rivers is occupied by deposits of Maw Gravels (see *Records, Geol. Surv. Ind.*, vol. XLVII, p. 32). The Maw Gravels had previously been tentatively correlated with the Irrawaddy Series owing to the discovery of a *Rhinocerotid*-tooth doubtfully assigned to *R. sivalensis*. Further collecting by Mr. Gupta has indicated that the Maw Gravels are as a whole older than the Irrawaddy Series, and must be assigned in part at least to a lower Siwalik age, owing to the occurrence of the following mammals:—*Diceratherium naricum* Pilg., *Aceratherium* *perimense* F. and C., *A. gajense* Pilg., *Tetrabelodon falconeri*, *Hemimeryx blanfordi* Lyd., *Anthracotherium silistrense* Pent., and *Dinotherium pentapotamiæ* Pilg. This fauna is clearly a Lower Siwalik fauna.

It must not be assumed however that the Maw Gravels are entirely Lower Siwalik in age. In the preceding field-season Mr. Gupta found near Ondwe in sheet 84 $\frac{K}{1}$, *Sus titan* Lyd., *Mastodon hasnoti ?* Pilg. and *Rhinoceros sivalensis* F. and C. This is indicative of a Middle Siwalik (possibly Dhok Pathan) age. The Maw Gravels may possibly therefore as a series, lie astride of the Pegu-Irrawaddy boundary of the Irrawaddy valley. It is however premature to discuss this at present, and it may merely be noted that an undoubted Lower Siwalik fauna has been discovered in them. The localities from which the Lower Siwalik fauna come are :—

(1) ½ mile west-south-west of Wekchiba (22° 4′ ; 94° 5′).
(2) ¾ mile north of Thaungbyin (22° 9′ ; 94° 9′).

The eastern boundary of the Maw Gravels is strike-faulted, the Laungshe Shales being in juxtaposition on the east, except in a portion of sheet $\frac{K}{1}$, where the following curious structure occurs. Along the eastern margin of the Maw Gravels near Shwekondaing and Semindaw villages is a series of shales with subordinate sandstones, which resemble very closely the Laungshe Shales. These shales were regarded as of Laungshe age and as part of the Laungshe outcrop, until on return to office a careful study of the fauna was made. During Dr. Cotter's visit to Mr. Gupta's camp in December 1922, some nummulites were discovered in the shales at the eastern boundary of the Maw Gravels. These nummulites proved to be *Nummulites yawensis* Cotter. Subsequently Mr. Gupta found *Operculina canalifera* (also a very common species of the Yaw Stage, although not confined to it), *Volutoconus birmanicus* Dalt. and a species of *Genotia*. The last two mollusca seem to indicate that the Yaw Stage is present here. If this be the case, it is necessary to suppose that there is in sheet $\frac{K}{1}$ a strip of Yaw Shales underlying the Maw Gravels, and west of the strike fault which elsewhere separates the Maw Gravels from the Laungshe Shales. The similarity of the Yaw Shales to the Laungshe Shales rendered it impossible to detect this occurrence in the field. The fauna of the Laungshe Shales, and in general the fossil horizons in these shales, bear a resemblance to the Des Vallev in Baluchistan (described in *Rec., Geol. Surv. Ind.*, XXXVI, p. 172 *et seq.*) in that we find a downward transition from the *Nummulites atacicus* horizon (equivalent to the Laki stage) to what may possibly be the *Cardita* (*Venericardia*) *beaumonti* horizon (Upper Cretaceous). *Nummulites atacicus* has been found at five localities (two in sheet 84 $\frac{K}{1}$ and three in 84 $\frac{J}{4}$), all at a fairly high horizon in the Laungshe stage. Lower down in the Laungshes, a fauna of distinctly Ranikot type, which was discovered in the preceding field season, has yielded the following species :—

Strepsidura indica C. & P.
Calyptrophorus indica C. & P.
Calyptrophorus hollandi C. & P.
Lyria cossmanni Vred.
Athleta euginae Vred.
Athleta burtoni Vred.
Athleta noetlingi C. & P.
Drillia inirakensis C. & P.
Murex lyalli D. Arch.
Volutilithes cf. cithara Lmk.
Faunus vulcanicus (Schl.)
Pyrazus pyramidatus (Desh.),

besides others not yet identified.

Only about 180 feet below this Ranikot fauna, a horizon containing *Orbitoides apiculata*, *Cinulia sp.*, *Roudairia sp.*, and *Orbitolina sp.* was discovered in the preceding season. Another species collected this year from the same horizon is *Cyprimeria sp.* possibly identical with *C. analoga* Forb. from the Cretaceous of South India. The fauna of this Orbitoides bed may possibly be Cretaceous, as has been suggested by Mr. Vredenburg (*Rec., Geol. Surv. Ind.*, vol. LV, p. 53). Owing to the presence of Nummulites in an apparently lower horizon of the Laungshes, Dr. Cotter was at first inclined to regard this bed as Eocene, but since a further study of the nummulite-bearing beds seems to point to their being a strip of Yaw Shales brought into juxtaposition with the Laungshes by strike faulting, it is no longer necessary to assume an Eocene age, and we may regard them as possibly upper Cretaceous. Mr. Gupta spent the latter part of the season in making some minor corrections in sheets 84 $\frac{K}{14}$, $\frac{K}{11}$ and $\frac{K}{15}$.

Betul District, Central Provinces.

In January 1923 Mr. H. Walker resumed the geological survey of the Betul District, Central Provinces. The area surveyed is represented on Degree Sheets Nos. $55\frac{G}{1}$, $\frac{G}{5}$ and $\frac{G}{9}$ of the one-inch Topographical Survey and forms part of the northern drainage area of the Tapti river. The work is a direct continuation of that of the previous season and, whilst revealing no new features, has confirmed the opinions expressed in 1922.

Central Provinces.

During the season 1922-23, Sub-Assistant Durgashankar Bhattacharji continued work in the districts of Nagpur, Chhindwara and Wardha. The first part of the season was spent in a search for inliers of infra-Trappean rocks with a view to estimating the depth of the Deccan Trap and assisting in the question of water-supply in the town of Nagpur. No inliers, excepting those described by W. T. Blanford, were found. The mapping of sheet no. $55\frac{O}{3}$ was completed. Beyond a few small outliers of trap and a few unmappably thin layers of Lameta beds, the area was found to consist of an intricate complex of metamorphic rocks.

Chitral.

Mr. G. H. Tipper resumed his work in Chitral and spent there the period from April to the middle of October 1923. He was accompanied by Mr. E. J. Bradshaw, one of the newly appointed Assistant Superintendents. Owing to the heavy snowfall of the previous winter and to the broken weather throughout the season some of the sections which ordinarily would have been easily visible could not be inspected. Heavy falls of snow as low as the 7,000 feet level took place early in September.

One of the most interesting sections seen was up the valley south-south-east from the village of Buni. Here the unfossiliferous lower Devonian limestones have been completely overfolded and faulted on both sides against narrow bands of Tertiary rocks, the Reshun conglomerates and shales. Associated with these Tertiary beds are Cretaceous limestones containing many *Hippurites* in a poor state of preservation. The latter beds are themselves faulted against the black slates and quartzites of the Chitral slate series. Still higher up there is evidence of another change of facies, a great mass of whitish quartzites are seen resting unconformably on the Chitral slates. In view of the Tertiary age of the Reshun conglomerates and shales, the suggested correlation between the succession in Chitral and that of the "Infra-Trias" and Attock slate series of Hazara loses much of its force.

[1]The high peak, Buni Zom (21,297′), and associated peaks are made up of banded gneisses and granites. Between Buni and Mastuj the road crosses the Reshun conglomerates and shales which are well exposed on the opposite bank of the river and beyond the conglomerates the Chitral slates are the only rocks seen. The gneisses and granites, however, continue to form the high peaks south of the road.

From Mastuj to Harchin the road lies among black slaty beds and quartzites, lithologically like the Chitral slate series. In the valley draining from the north-west the Reshun conglomerate and shales are met with again. This is the continuation of the band seen last year running up the Shishi valley. The section at Harchin is, however, not very well seen. This band runs to the N. E. and forms the top of the Chamarkand pass where it has thickened a good deal and the conglomerate is very massive. It was unfortunate that the pass was under thick snow at the time, as the section promises to be a good one.

The descent from the pass to the camping ground at Chamarkand reveals a section in many respects similar to that exposed in the neighbourhood of Kala Drosh, and is very obviously a continuation of that seen by the late Sir Henry Hayden at Amurchat in Gilgit territory, although not quite so extensive. The Orbitolina limestones (middle Cretaceous) are present together with some trap beds. These beds abut on a mass of granite similar in all respects to that exposed at Mirkanni and at various places in the Shishi valley. Still further to the north-east the section is much thinner but the Reshun conglomerates and shales continue to form a well-marked band.

From Chapari, the hamlet at the place where the Chamarkand stream joins the Mastuj river, to the Baroghil pass, the traverse has already been so well described by Sir Henry Hayden that very little can be added. Details of sections have been obtained from the valleys on the left bank of the river, and the narrow band of semi-crystalline limestones which crosses the river at Tirbut has fortunately yielded a few recognisable fossils. There are some *Bellerophon* and some *Fusulinæ*, so similar to those from the Baro-

[1] See Imp. Gazetteer, India, Vol. I, p. 67 (1907).

ghil section as to leave no doubt that this band of limestone is of Carboniferous age.

In his description of the Baroghil section Sir Henry Hayden mentions a narrow band of ferruginous rocks which are faulted in amongst the *Fusulina* limestones. Traced eastwards this band thickens and becomes fossiliferous. Similar rocks and fossils are seen resting on the Permo-Triassic rocks of the Shawitakh pass. On the road to Shawar Shur these same rocks are seen occupying the centre of an overfold which has led to the reduplication of the *Fusulina* and other limestones, the latter rocks forming high scarps to the north of Shawar. From the fossils obtained these ferruginous rocks appear to be of upper Devonian age. They occur again in the hills on the right bank of the Karambar valley and again also on the right bank of the large glacier south-east of Shawar Shur. The structure is one of considerable complexity.

The hills to the west of the Baroghil which promised to give a very fine fossiliferous section are disappointing, particularly as regards the Carboniferous and Permo-Triassic rocks. These rocks are much more highly disturbed and have become practically unfossiliferous, being converted into semi-crystalline limestones in which traces of fossils only are visible. The lower beds (ferruginous beds similar to those of the Shawitakh and Shawar-Shur) are, however, very fossiliferous and there are signs of a distinct faulted junction between them and the upper beds. The general strike of all these formations at the Baroghil is E. to W.

Between the Baroghil and the Kankhun pass, parallel to the former and about 14 miles distant to the west, the rocks are much disturbed by a boss of granite and the Kankhun pass, instead of yielding a good section similar to that of the Baroghil, merely reveals masses of unfossiliferous marbles and black slates striking generally N. E.—S.W. Another great mass of granite, a little further west, has still further disturbed and metamorphosed the rocks. The good sections to be seen on the road across the Shah Janali pass and in the upper Turikho valley show that such limestones as do occur have been converted into unfossiliferous crystalline limestones and the shaly beds into slates and schists. Signs of movement are very apparent in the folding of all the rocks, the thickening of the limestones and in the presence of many brecciated bands. It is probable that the greater part of the altered limestones are the representatives of the limestones of the Baroghil but in the absence of any reliable fossil evidence it is impossible to place them in their proper sequence.

There is one unit exposed in the upper Turikho which deserves special mention. This commences in the neighbourhood of the Shah Janali pass as a series of black slates, grits and quartzites with some conglomerate bands. The outcrop gradually increases in breadth owing to the intercalation of epidotised trap rocks, of masses of conglomerate composed of white rounded quartz pebbles in a red ferruginous matrix and also of some detrital rocks of volcanic origin. Traced to the south-west these rocks pass into the softer black shales and quartzites forming the Kosht ridge. To these Sir Henry Hayden gave the name of Sarikol shales, from lithological similarity, and also suggested a lower Carboniferous age. The rocks are generally unfossiliferous but occasionally contain *Orthoceras* and crinoid stems. In the neighbourhood of Werkap a band of limestone occurs as part of these beds and is very fossiliferous. An examination of the fossils suggests that the limestones are probably upper Devonian and it may be that these beds are the continuation of the ferruginous beds of the Baroghil section.

At the end of the season an opportunity occurred for the re-examination of the fine section between Reri and Owir, along the Owir gorge. Although not quite so extensive as that of the Baroghil, the upper Devonian yielded a number of good fossils. As at the Baroghil there is a considerable thickness of beds above the horizon of the Koragh spur and Shugram which contain typical upper Devonian fossils. It was in this section that the peculiar pseudo-conglomeratic coral limestone was found; this band is so distinctive that it has been of great assistance in mapping detached outcrops.

The *Orbitolina* limestones of middle Cretaceous age in the Drosh valley have been traced along the edge of the river from just below Drosh fort to the cliffs opposite Suir. At the latter place the section exposed is more complete than at any other point. The limestones are sheared with the consequent destruction of the larger fossils. *Orbitolina* occurs in the more shaly bands between the massive limestone bands. The junction with the traps of the valley is always one of unconformity. The junction with the overlying beds is generally obscured by the alluvium of the river-bed. The fossiliferous Cretaceous beds do not continue along the strike either to the north-east or south-west, although a very thorough search has been made in these directions. It is unfortunate that this datable deposit is of little use for the elucidation of the structure of the Drosh valley.

During last year it was pointed out that the Mirkanni granite is intimately associated with basic traps. Further examination of the sections near Mirkanni, Naghar, Badurgal and other places shows, according to Mr. Tipper, that the typical Mirkanni granite passes laterally through a diorite into a doleritic trap rock. It is this latter rock which occupies a considerable portion of the left bank of the Drosh valley.

Mr. Tipper notes one of the main agencies of denudation in Chitral which seems to have escaped previous observers. This consists of mud slides, the most destructive of which occur after heavy torrential rain such as that which accompanied thunderstorms during August of the year under review. This rain sweeps the small stones, dust, etc., from the hill sides into the stream beds. The material banks up and accumulates at the mouth of the stream where there is generally a gorge, and when the pressure has accumulated sufficiently, a stream of liquid mud, stones and boulders bursts through the obstruction and carries everything before it. The effect of these mud slides is amazing. In August, 1923, one came down through Chitral, a stream of mud and boulders of varying sizes. The material brought down blocked the main river threatening the fort of His Highness the Mehtar. The bursting of this temporary dam washed away the suspension bridge at the Government fort 1 mile below. The amount of damage done by these mud slides depends upon the character of the stream bed. When this has cut a fairly deep channel through the alluvial fan, the mud may be, and often is, confined between its banks, little material damage resulting. Where the stream bed spills on to the highest point of the fan, a mud slide simply spreads out destroying crops, gardens and houses, carrying away anything in its path. No part of the country is free from them. The amount of material thus transported is great and there is no doubt that the alluvial fans are chiefly built up in this way.

Hyderabad, Deccan.

During the field-season 1922-23, a further 902 square miles of the country west of Hyderabad were geologically surveyed by Mr. K. A. K. Hallowes. These areas are composed of biotite-granite gneiss containing much microcline and micro-pegmatite, probably of Archæan age, traversed by a network of numerous quartz reefs and intersecting altered dolerite (epidiorite) dykes, and covered in part by four flows of Deccan Trap. The granite-gneiss shows the same uniformity of composition over large areas, the biotite being rarely replaced partly or entirely by hornblende. It is in all probability an ortho-gneiss. Rare occurrences of epidote-granite gneiss are met with, and the granite-gneisses marginal to the epidiorite dykes are characterised by hornblende. Basic patches, *schlieren*, or cognate xenoliths occur, composed of either sphene, black iron-ore, apatite and epidote along with crowded flakes of chloritized biotite, or of a dense aggregate of flakes of bluish-green uralitic hornblende associated with many grains of epidote and sphene; both types are set within a ground-mass of ordinary biotite-granite-gneiss. Intruded into these ortho-gneisses are rare pegmatite veins composed of hieroglyphic intergrowths of glassy quartz with pink orthoclase or microcline. Quartz reefs, which are well jointed and non-auriferous, traverse the granite-gneisses; these are sometimes faulted, and are invariably older than the epidiorite dykes, for in every case the latter are seen to cut across them. Of the thirty-five quartz reefs which occur in the area and which vary in width from 15 to 100 paces, the majority strike N. E.—S. W. The epidiorite dykes vary in width from 10-110 paces, and are far more numerous than the quartz reefs, for there are one hundred and fifty-nine. All the basic dykes, except a few of amphibolite, are composed of altered dolerite (epidiorite), which is occasionally coarsely porphyritic. They frequently branch, and intersect each other, and their course is often curved. The majority of them strike more or less due east and west. Some of the dykes contain micro-pegmatite in which there is seen a tendency to radial structure similar to that in a granophyre. Very often the structure of their mass is highly granulitic. Between the granite-gneiss and the Deccan Trap series are the boundary "Red and White Beds." Fossiliferous Lameta beds were met with at two localities only. Two furlongs south-south-west of Nawaapet, (17° 43′ 30″ : 78° 23′ 45″), is a thin lenticular bed of pale calcareous Lameta shale resting directly upon calcified hornblende granite-gneiss covered by Deccan Trap basalts. This bed contains in large numbers a fossil fresh-water *Unio* belonging to an undescribed species of the new genus *Indonaia*.

One mile north-north-west of Anantawaram, between the first basalt flow and the underlying biotite-granite-gneiss, a brown chert containing indeterminable fossil fragments, probably of *Unionidæ*, occurs. A part of the gneissic area is covered by four separate horizontal flows of Deccan Trap, but the small outliers of the latter indicate a former wider extension, which probably included the site of the city of Hyderabad. West and south-west of Hyderabad, the ragged edges of the four basalt flows which have been cut back may be observed. None of the four basalt flows are olivine-bearing; their thicknesses from below upwards are respectively 34 feet, 111 feet, 96 feet and 74 feet. Between these basalt flows are inter-Trappean beds of green earth, limestone, chert and geode-bearing vesicular basalt.

Punjab and Poonch.

The first part of the field season was spent by Mr. D. N. Wadia in a continuation of his mapping of the Rawalpindi district. In the country between Mozaffarabad and Jhelum the entire zone of hills has been subject to a geniculate bend of nearly 110°, the axis of the "knee" being the Jhelum River.

During the latter half of the season the survey of the Poonch *Ilaqa* was completed. In last year's report it was stated that the suggestion that the Kiol or Kuling beds of Lydekker included Nummulitic strata was confirmed by the discovery of nummulites by Mr. Wadia. These specimens have since been subjected to more careful examination, and although the imperfect fragments decidedly resemble nummulites, they are, according to Mr. Tipper, more probably members of the *Fusulinidæ*. The Nummulitic age of part of these beds must therefore be regarded as not yet definitely proven. In the Mendhar and Bagh *tahsils* it has been found possible to split the Murree series into two stages, an upper and a lower, based on lithological differences and on the frequent presence of plant remains and woody tissue in the upper.

Rajputana.

During the field-season the Rajputana party resumed the geological survey of Rajputana which had been interrupted in 1916 by economic enquiries connected with the War, and had not been since resumed except for a visit to the Jodhpur part of the area by Messrs. Tipper and Crookshank in the field-season of 1920-21 (*vide* General Report for 1921). The party consisted of Dr. A. M. Heron, officiating Superintendent in charge, with Sub-assistants B. C. Gupta and L. A. N. Iyer, under training. The survey was taken up in the neighbourhood of Beawar, where it had been discontinued in 1916, and during the season three standard sheets, on the 1-inch-to-1-mile scale, Nos. 165, 166 and 167 of the Central India and Rajputana Survey, were completed except for a portion of the Udaipur (Mewar) State in the south-east. The adjoining portions of sheets 140 and 168 were also touched on. Politically the area surveyed consists of the major portion of the Merwara sub-division of the British district of Ajmer-Merwara, and of a part of the Jaitaran *pargana* of Jodhpur (Marwar) State, adjoining Merwara along its north-western border.

Topographically the area is characterised by its division into five zones, which extend in an approximately N. E.—S. W. direction, the general strike of the rocks; this physiographical division reflects with great faithfulness the geological structure. Rocks belonging to two systems are present in alternate zones, two of these being occupied by varied metamorphics of the younger system correlated with the Delhi system of Jaipur and Alwar and three by gneisses of the older group, which we may consider as probably belonging to the Aravalli system. So far we do not know the relationship of the Aravallis of north-eastern Rajputana and Jaipur to the gneisses and biotite-schists of the great plain of Kishengarh and south-eastern Ajmer, but the two groups are similar, except that in the latter the proportion of granites and banded granite-gneisses is higher. This increase in the amount of igneous intrusion is quite in accordance with the other observations, from which we infer that as we go westwards, transverse to the axes of folding which determine the "grain" of the country, from Alwar through Jaipur to Ajmer, we are passing from the flanking folds of the ancient Aravalli chain to its central core where metamorphism and igneous permeation reach their maxima. We may perhaps consider the Aravalli system to be part of the Archæan, at any rate the older rocks of this system are of typically Archæan facies.

Only the central and the north-western belts of the older rocks were examined this year, with a narrow strip of the south-eastern belt where it underlies the newer system. Dr. Heron reports that in the north-western belt the most prominent rocks are a group of limestones in massive beds, overfolded in several isoclines, the axial planes of which dip to the north-west at high angles. They form high, straight and almost continuous ridges extending for about 50 miles, and the celebrated marble of Makrana in Jodhpur appears to occur along their strike continuation to the north-east. For the most part they are coarse, white, saccharoidal marbles, with diopside and white mica; interbedded with them are bands of finer and less crystalline, blue-grey, "sandy" limestone, the "sandy" appearance being due to knots of secondary felspar, quartz and calc-silicates weathering in high relief. Dark calc-gneisses occur sparsely. Lapping round the ridges and exposed in valleys between them, in such a manner as to suggest that the limestones are folded into it, is a grey, foliated, porphyritic gneiss of a fairly uniform granitic composition, which comprises the remainder of the north-western belt of older rocks. This is probably a granite magma which has invaded the limestone series, removing or absorbing the non-calcareous portion of the assemblage, or it may be the result of the complete metamorphism and recrystallisation of the non-calcareous members of the series. The contact between limestone and gneiss is sharp, and there is no passage of one into the other. The gneiss is much intruded by later pegmatites, which are absent from the limestones.

The central belt is composed of porphyritic banded gneisses which are in part the dark Aravalli porphyritic biotitic granite, often bearing garnet and magnetite, and in part biotite schists injected with this granite and later acidic granite and pegmatite, the various types being interbanded and rolled out together in the greatest complexity. To the south-west this band narrows and is finally eliminated by the convergence of the two flanking synclines of the younger series, while to the north of Beawar it disappears beneath alluvium. Along it runs a line of small plugs of a comparatively little-altered dolerite, which is probably the latest intrusive here present.

Only the north-western edge of the south-eastern Aravalli area was examined. The dead-level plain which stretches through south-eastern Ajmer and the Kishengarh and Jaipur States is almost unbroken except for a few hills composed of outliers of the Delhi system. Along the edge runs a narrow band of the dark porphyritic gneiss, varying in all degrees from a coarse biotitic granite through banded varieties to a fine mylonite with the felspars entirely destroyed. Beyond this is a wide extent of biotite schists and granulites, intruded by large and small bodies of the Aravalli granitic gneisses and saturated with pegmatite from that granite, forming the "migmatite" of Sederholm. These schists are the oldest rocks met with, and in them the gneiss (really a foliated granite) is intrusive, with its pegmatite, other younger fine-grained acid granites, epidiorites (amphibolites), pegmatite from the post-Delhi granite magma, and still later doleritic rocks.

Shearing and mylonisation occur principally along the contact with the younger series and have been caused by the sliding of the younger syncline over the older complex, with an imposing development of shear-breccias, "flinty crush-rocks" and "trap-*schotten* gneiss."

Alternating with the three belts of older rocks, the younger system is exposed in two symmetrical isoclines, dipping in general towards the north-west. In the type area of the Delhi system, Alwar and Jaipur, it is broadly divisible into the Alwar series, a great thickness of quartzites, succeeded upwards by the Ajabgarh series, and by as great or even greater a thickness of argillaceous and somewhat calcareous rocks. Round Ajmer quartzites are in force, but in this season's area they have disappeared except for puny representatives; it is not yet clear whether their absence is due to their having died out to the southward, with the upper argillaceous and calcareous series overlapping them on to the Aravalli system.

Only a very general agreement can be made out between the succession in the two synclines, and each is in itself quite asymmetrical. This is no doubt due to intensely compressed folding with "sliding" and overthrusting, resulting in the partial elimination of one limb of the syncline, as is the case in the Alps and the Highlands of Scotland. Unfortunately in the Aravalli range the folds never approach horizontality, their axial planes generally dipping north-westward at angles from 50° to vertical; this and the moderate height of the ridges render available only very short sections for study along the direction of dip; consequently thrust-planes are almost impossible to trace in such highly folded rocks. It is still hoped, however, that further strike-mapping may clear away some of the complexities.

Dr. Heron reports that, commencing with the south-eastern margin of the south-eastern syncline, the basement bed, resting on the older complex, is a thin arkose quartzite. This is continuous along the strike with the great unconformity conglomerate which between Srinagar and Kishengarh has a breadth of outcrop of over a mile; this, allowing for the folding seen in it, gives a thickness of from one to two thousand feet. This conglomerate is composed of quartz and quartzite pebbles with abundant felspar fragments derived from the Aravalli pegmatite, all much compressed and recrystallised; in certain beds occurs a boulder conglomerate resembling that at Bar. On some portions of the line of unconformity the thin quartzite is eliminated by thrust-faulting; in others it is repeated, and in the south of the area surveyed expands again into a thick felspathic conglomerate like that of Srinagar. Above is a carbonaceous limestone—only locally present—containing wollastonite, and biotite-granulites, succeeded by a thin and very persistent quartzite. Then follows a thickness of about 3,000 feet of biotitic and siliceous limestones, folded in an isoclinal syncline with dips to the north-west. This syncline rises as it is followed to the south-west, and is succeeded further along the strike by other indefinite areas of similar limestone which is complicated folded and intimately associated with calc-schists. The latter are extremely flaggy rocks consisting essentially of tremolite, quartz and felspar, with varying amounts of biotite and calcite, and there is no doubt that their present banding, in endless alternations of layers varying in the proportion of tremolite or calcite with biotite, represents their original stratification and that the tremolitic facies and the biotite-calcite facies are essentially modifications of the same thing. They have a general anticlinal lie, with complicated minor corrugations, and are everywhere injected, to a profuse degree, with tourmaline-muscovite-pegmatites in dykes, sills and masses up to two miles long and a mile wide. This is the pegmatite from the later post-Delhi granite, and it is practically absent from the limestones. From the field evidence however, Dr. Heron is of opinion that pegmatite intrusion is not the *cause* of the production of the tremolite of the calc-schists; its preponderance in the calc-schists, and even more so in biotite schists, is possibly due to mechanical causes, such as the fissility of the biotite schists, and, due to the calc-schists, reduction of volume, allowing fissuring, due to the crystallisation of amphibole. Along their north-western margin the calc-schists dip under biotite schists, frequently garnetiferous, which with three bands of somewhat irregular quartzites, make up the north-western third of the syncline. In this portion dips are uniformly to the north-west, according to the prevailing habit, and the lowest bed, the boundary quartzite, is thus inverted under the older gneisses of the central Aravalli belt. The basement quartzite is thin and not notably felspathic, but immediately above it is a considerable development of felspathic schists—originally arkose. In this portion also pegmatite has an enormous development, especially towards the south-west, where the mode of intrusion changes from that of dykes and sills to minute interfoliar injection, resulting in the regional production of "injection gneiss" or "migmatite."

The north-western syncline may be considered as two broad zones running along its length, in the direction of the strike. The south-eastern zone, which is by far the broader, consists of an inextricable complex of—to mention the chief types only—calc-gneisses, biotite-schists and felspathic schists (arkose) with irregular masses of biotitic limestone, talc and chlorite schists, and irregular lenticular quartzites, which are siliceous modifications of the calc-gneiss, and white crystalline limestones near its north-eastern margin. No plan of folding can be made out, but wherever any large surface of calc-gneiss is exposed, the most remarkable crumpling is seen, showing that deep-seated folding has carried this assemblage well within "the zone of flowage," where the rocks have acted as if they were plastic under enormous pressure. No continuity of type is maintained as any given band is followed along the strike, and it is probable that the whole complex is a mass of corrugations, pinched out and pitching steeply. It is believed that this complex is to be correlated with the tremolitic calc-schists and biotitic limestones of the other syncline, with which it has a general resemblance, allowing for the intenser and more deep-seated folding and metamorphism undergone. The term "calc-gneiss" instead of "calc-schist" is here used to indicate that the banding of the rocks is on a considerably bolder scale. A quartzite or arkose is present, in places, on the margin with the Aravalli gneisses of the central belt, but, as often as not, this has been obliterated by the thrusting of the syncline on the older system.

Pegmatite veins are, except on its margins, practically absent from the north-western syncline, but the hypothesis that tectonic movements have carried it to a greater depth in the earth's crust than has happened to the south-eastern syncline, is supported by the presence of numerous bosses of intrusive granite, the deeper-seated equivalent of pegmatite. In addition, veins of fine-grained aplitic granite are numerous, and there is a great abundance of varied amphibolitic rocks, some of which are undoubtedly intrusive, while others may be metamorphosed effusives and pyroclastics. To the north-east, where the syncline opens out, dips lessen, and the structure can be seen, an immense thickness of these hornblende schists, is exposed, resting on the mixed rocks of the complex.

The north-western and much narrower portion of the syncline is separated from the assemblage just described, by a persistent, fine-grained, white limestone, without stratigraphic discordance on either side. From here to the south-west base of the syncline much more regularity is apparent, the beds being vertical and the divisions being traceable for about 30 miles along the strike, except in so far as they are obscured by epidiorite intrusions; passing from the limestone they consist, in order, of felspathic schist (arkose) with local limestones, biotitic-schist, biotitic limestone, biotitic-schist and the Bar conglomerate. This last is a remarkable bed, extending along the strike for 30 miles and having a measured thickness of 1,000 feet. It is composed of boulders and pebbles of grey quartzite and of gneiss, derived from the underlying older system, which are flattened and drawn out in an extraordinary way in the direction of the dip so that their greatest dimension is ten to twenty times their least; in shape they are best likened to cuttle-bones.

North of where the Bar conglomerate dies out is a very large intrusion of the post-Delhi granite, 26 miles long by 4 miles wide, which abuts against the Aravalli gneiss on one side and the basal beds of the syncline of Delhi rocks on the other; against the former it has an abrupt margin and is easily distinguished from it by its coarseness of texture, the presence of tourmaline in acid segregations, and other lithological differences.

Sub-Assistants Barada Charan Gupta and L. A. Narayana Iyer accompanied Dr. Heron for instruction and training.

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A GEOGRAPHICAL CLASSIFICATION OF THE MINERAL DEPOSITS OF BURMA. BY J. COGGIN BROWN, O.B.E., D.SC., M.I.M.M., M.I.M.E., F.G.S., *Superintendent. Geological Survey of India.* (With Plate I).

CONTENTS.

INTRODUCTION.

THE mineral deposits of Burma may be classified into a number of more or less well defined geographical groups, each of which is built up of rocks belonging to contemporaneous geological periods, marked by the effects of the same diastrophic events and characterised by certain mineral associations often prevalent over areas of considerable extent. These groups may be named as follows: (See Table 1.)

A Classification of the Mineral Deposits of Burma.

No.	Group.	Sub-group.	Stratified Rocks.	Typical Igneous Rocks.	Chief Minerals.
1	Arakan-Naga .	...	Metamorphosed sediments of Triassic and Cretaceous age in part.	Peridotites and serpentine.	Chromite, native copper, chalcocite, platinum, osmiridium, gold, chrysotile, steatite, magnesite.
		Tawmaw . .	....	Serpentine . . .	Jadeite.
2	Pegu Gulf . .	..	Eocene to Recent . . .	....	Petroleum, coal, amber.
3	Mogok-Frontier .	..	Archæan gneisses, crystalline limestones.	Intrusive granite . .	Ruby, sapphire, spinel, graphite.
4	Mingin . . .	..	....	Quartz diorite . .	Gold, chalcopyrite, pyrite, galena, franklinite, altaite.
5	Chaung Magyi .	..	Mica-schists, slates, phyllites, quartzites.	Biotite granite . .	Gold.
6	Shan-Yunnan .	..	Cambrian ? Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic.	Rhyolites and tuffs at base of Ordovician.	Galena, zinc blende, chalcopyrite, pyrite, stibnite.
7	Tenasserim . .	..	Argillites, slates, quartzites. Age unknown.	Granite	Wolfram, cassiterite, molybdenite, bismuthinite, native bismuth, chalcopyrite, arsenopyrite, pyrite, zinc blende, stibnite.

Plio-pleistocene and Recent deposits include :—

Lignite Deposits of the Shan States and Tenasserim. Oil Shales of Amherst. Residual Iron Ores of the Shan States.
Gem-gravels of Mogok.
Gold and Platinum placers of the Irrawaddy, Chindwin, etc.
Eluvial wolfram and cassiterite deposits of Tavoy, Mergui, etc.
Alluvial Cassiterite deposits of Tavoy, Mergui and Amherst.
Manganese ores of Myingyan and Meiktila.
Soap sands of the "Dry Zone," etc.

1. The Arakan-Naga Region, composed of very folded and altered strata, of pre-Tertiary and perhaps mainly Mesozoic age, penetrated in many places by ultra-basic rocks, which are often changed into serpentine, and bearing chromite, native copper, chalcocite, platinum?, osmiridium?, gold?, chrysotile, steatite and magnesite. The Tawmaw serpentine-jadeite sub-group is included here, though it is not known definitely that the serpentines of the larger region continue across to it in an unbroken lime.

2. The Pegu Gulf, composed of Tertiary rocks, ranging in a complete sequence from the Eocene to the Pliocene and containing hydrocarbons, petroleum, coal and amber.

3. The Mogok-Frontier Region built up of gneisses and crystalline limestones. The gneisses are usually of a biotitic character and are frequently invaded by granites and pegmatites. The crystalline limestones contain rubies, sapphires, spinels and other gem stones as well as graphite.

4. The Mingin Group. A comparatively small, and, as far as known at present, unique area characterised by quartz diorites intrusive into tuffs and other volcanic rocks, and carrying gold-telluride quartz veins containing gold, chalcopyrite, pyrite, galena, franklinite and altaite, the telluride of lead.

5. The Chaung Magyi Group, including both the mica schists of Mong-Long, and the slates, phyllites and quartzites of the Chaung Magyi Series proper. Dykes of intrusive tourmaline granite occur in the mica schists and large boss-intrusions of biotite granite in the Chaung Magyi rocks. Both series are traversed by quartz veins, usually barren, but occasionally carrying gold.

6. The Shan-Yunnan Region, composed chiefly of sedimentary rocks ranging in age from Ordovician to Jurassic. Intrusive rocks are rare but in places islands of strata belonging to the Chaung Magyi group reach the surface. The metallogenetic sequence is essentially a sulphidic one, argentiferous galena, zinc blende, chalcopyrite, pyrite and stibnite. A solitary coal field of Jurassic age is known.

7. The Tenasserim Region, made up of granite intrusive into sediments of unknown age. The predominating minerals are wolfram and cassiterite with smaller amounts of molybdenite, bismuthinite, native bismuth, chalcopyrite, pyrite, arsenopyrite, zinc blende and stibnite. Large portions of this region are occupied by limestone, probably of Upper Palæozoic age, but the geological survey of

Burma has not progressed far enough for these to be separated yet, or for their relations with the granite to be explained.

8. Under a separate head must be included the Plio-Pleistocene and Recent deposits scattered throughout Burma, which contain minerals of present or potential value; such as the lignite and peat deposits of the Shan States, the oil shales of Amherst, the residual iron ores of the North Shan States and elsewhere, the surface manganese ores of Meiktila, the laterite of Lower Burma, the hill and lake gem-gravels of the ruby mines, the gold and platinum placer deposits of the Irrawaddy, Chindwin and other rivers, the eluvial wolfram and cassiterite deposits and the alluvial cassiterite-bearing sands of Tavoy and Mergui, the soap sands of the "Dry Zone", etc. It is not proposed to describe these separately and in detail here but they will be mentioned as occasion arises.

THE ARAKAN-NAGA REGION.

Orography.

The mountain chain of which the Arakan Yoma forms the southern part stretches in a double convex arc for 1,500 miles of which 400 are under the sea. The submarine portion is south of latitude 16° but it appears again in the Andaman and Nicobar Islands attaining therein heights of over 2,000 feet. In Burma it borders the western edge of the Irrawaddy and Chindwin valleys and up to latitude 21° its trend is approximately north-north-west with peaks of over 4,000 and 6,000 feet. Beyond this region, where it enters the hill tracts of Pakokku and Northern Arakan, it begins to lose the individuality it possesses further south in groups of more or less parallel ranges directed north and south. Further north still, in Manipur and the Naga Hills, the ridges bend round to the north-east and converge into the Patkoi Range and its offshoots, which continue till they meet the north and south folds of the frontier system. Mount Victoria in the Pakokku Hill Tracts is over 10,000 feet high, while in Manipur and the Naga Hills there are peaks of over 6,000, 7,000 and 8,000 feet respectively.

The whole country is covered with dense vegetation, its structure is complicated and appears to possess few beds of marked particularity, it is inhabited by tribes of doubtful temperament and the movements of the few geologists who have worked in it have usually been guided by those of the armed forces they accompanied.

Geology.

In whatever way it is regarded, the Arakan-Naga province stands alone in Burma. Its structure, at any rate as far as the southern portion is concerned, is that of a great anticlinorium containing, according to E. H. Pascoe, a number of tight subordinate folds[1]. Moreover, it is complicated by igneous intrusions and certainly not simplified by its participation in comparatively late earth movements. It is not my purpose here to summarise or to attempt to correlate the descriptions of the rock groups met with on the various traverses that have been made from time to time into the Arakan-Naga region, but merely to point out that amongst the crushed, hardened and altered rocks which form its core a few fossils both of Triassic and Upper Cretaceous age have been found. Along part of its eastern margin in the districts of Minbu and Pakokku there is a thick band of hardened Eocene conglomerates followed by the Tertiary sequence of the Irrawaddy and Chindwin rivers, and the Tertiary deposits of its western flanks, that is, those laid down in the "Assam Gulf," though synchronous, are not identical. It follows that the folding which raised the Arakan Yoma and the associated mountain ranges of the Arakan-Naga region was initiated in the late Cretaceous and that part, if not the whole of it existed as land throughout the Tertiary period, forming a barrier between the two gulfs. Further, there is evidence that the geoanticline of the Arakan-Naga region was subjected to elevatory movements during the Tertiary period while the corresponding geosyncline of the Pegu gulf suffered secular depressions. In the extreme north, T. H. D. LaTouche found Tertiary rocks occupying the whole valley of the Dehing river and it may well be that here they stretch right across from Upper Assam to Burma, lying unconformably upon the crystallines of the Frontier ranges[2]. Stuart crossed the Patkoi Range recently[3] from the head of the Assam valley to the Hukong Valley in Burma and although he describes the structure of the Patkai as that of a broad syncline, the axis of which is approximately coincident with the crest of the range, and across which sandstones of Upper Tertiary age extend, his map shows a broad expanse of pre-Tertiary deposits in a parallel ridge, nearer Burma, with the Tertiary deposits dipping away from them at high angles to the north-west and

[1] E. H. Pascoe: (56), p. 250.
[2] T. H. D. LaTouche: (37), pp. 111-115.
[3] M. Stuart: (64), pp. 398-411.

south-east. Stuart correlates these with the pre-Tertiaries of the core of the Arakan Yoma far to the south-south-west.

Igneous Rocks of the Arakan-Naga Province.

So little is known of the Arakan-Naga Region that, it would appear premature to discuss its minero-genetic features, yet the few outstanding facts which we do possess are of sufficient importance to warrant certain definite conclusions. These are as follow :—

(1) Throughout the whole region so far as it has been examined not a single exposure of an acidic igneous rock of the granitic type has been recorded.

(2) Intrusive serpentines have been found on practically every traverse.

(3) The scanty occurrences of metallic minerals that are known, and none of them have proved to be of economic importance as yet, are such as would be expected to occur in an ore-province characterised by the predominance of ultra-basic rocks. They are chromite, native copper and chalcocite with the nonmetallic minerals of potential value,—steatite, chrysotile, and magnesite.

Distribution of the Serpentines of the Arakan-Naga Province.

In the Andaman Islands the chief igneous rock is a dark green serpentine with veins of chrysotile ; the other types are a bronzite-olivine-picotite peridotite and a diorite. Serpentine pebbles often form part of the Eocene conglomerates of North Andaman Island. Serpentines, gabbros and diorites also occur in the Nicobar Islands. G. H. Tipper believes that the intrusions are of upper Cretaceous age.[1] Serpentines are common in the foothills of the Arakan Yoma of the Henzada, Prome and Thayetmyo districts. In Prome the rock frequently passes into gabbro with porphyritic crystals of bronzite. It is intersected by veins of gold-coloured chrysotile, or sometimes of magnesite. To the west of Thayetmyo town there is a serpentine intrusion some 5 miles long. In the western part of the Henzada district there are 21 distinct and isolated occurrences scattered over a length of 26 miles from north to south.[2] The steatite deposits of eastern Kyaukpyu, of Minbu and probably those of Pakokku too, occur in serpentine. "The steatite occurs in veins traversing the dark green intrusive serpentine which is found in such quantities in the Arakan Yoma" wrote Sir Henry Hayden.[3] The beds

[1] G. H. Tipper : (66), pp. 10-11.
[2] W. Theobald : (65), pp. 189-359 ; R. D. Oldham : (53), pp. 146-147.
[3] H. H. Hayden : (29), p. 71.

below the basal Eocene conglomerate of the Minbu and Pakokku districts are ashy and there are numerous outcrops of serpentine along this horizon according to G. de P. Cotter.[1] In the Manipur Hills, R. D. Oldham mapped a serpentine band 40 miles long and a mile or two in breadth, which is so similar to the rocks described by Theobald that Oldham deliberately chose the former's words to describe it. This example is, like so many of the others, confined to the eastern limits of the hill rocks.[2] Corresponding to this band, E. H. Pascoe found serpentine further north in the Naga Hills.[3] Thus between Puchinui and Karauni they form "a line of conical crag-crowned hills". The rock consists of a confused mass of massive and fibrous serpentine. In other places the serpentine with its associated chrysotile and chlorite has to a large extent become schistose. Boulders of the following rock types, believed to be at least in part responsible for the formation of the serpentine, were collected by Pascoe:—hornblende-enstatite-olivine gabbro, diallage gabbro, serpentinized lherzolite, spinellid peridotite altering into serpentine. In his brief notes of the geology of the Upper Chindwin valley the late H. S. Bion showed how the Tertiaries dip steeply off the complex of pre-Tertiary rocks in Manipur, and in the north come to an abrupt end against a deeply dissected mountainous area occupied by cleaved sediments. These lie exactly on the strike of similar strata found by Pascoe around Sarameti Peak in the Naga Hills. Further, a great many large boulders of serpentine occur in the upper reaches of the Chindwin River. There can "be no doubt", wrote Bion, "that the belt of intrusive serpentine which occurs along the boundary of the so-called Axials of the Arakan Yoma, Manipur and the Naga Hills, extends to the west of the Tertiary basin and crosses the Chindwin river a few miles above the Kyaukse rapids".[4] To the far north in the valley of the Dehing river LaTouche observed large, transported blocks of serpentine,[5] while Stuart found serpentine intrusions in the pre-Tertiary rocks of the Patkai Range between Upper Assam and Burma.[6] It appears to be very generally believed that the serpentines are of Upper Cretaceous age and almost all the occurrences

[1] G. de P. Cotter: (21), p. 413.
[2] R. D. Oldham: (52), pp. 217-242.
[3] E. H. Pascoe: (57), pp. 258-259.
[4] H. S. Bion: (3), pp. 244-245.
[5] T. H. D. LaTouche: (37), p. 113.
[6] M. Stuart: (66), p. 402.

are on the eastern or Burmese flanks of the watershed. Oldham has stated that not a single intrusion has been detected in the unaltered Nummulitic rocks,[1] but at a later date, Stuart maintained that certain intrusions of the Henzada district traverse coal-bearing sandstones which he correlates provisionally with the Laki Stage (Middle Eocene).[2]

Types of Minerals found with the Serpentines :—Chromite and Platinum.

The occurrences of chrysotile and steatite have already been alluded to. Chromite appears to be frequent in the ultrabasic rocks and to have been found wherever it has been especially searched for. It was reported from the vicinity of Port Blair in the Andaman Islands as long ago as 1883,[3] and it is known from various localities in the Arakan Yoma and its extensions to as far north as the jade mines of Tawmaw which I regard as belonging to a sub-province of the same type as the Arakan-Naga one. H. S. Bion found rhombohedra of magnesite in a boulder of serpentine from the Upper Chindwin river. He also discovered small pockets of chromite in the serpentines near Sibong in Manipur. In discussing the origin of the platinum and osmiridium, which occur in very small quantities, but almost universally with the placer gold of the Chindwin and its tributaries, he drew attention to the well-known, world-wide association of platinum with chromite segregations and serpentine. He mentioned that a belt of serpentine does extend from the Andamans, more or less continuously, through the Arakan Yoma, Manipur, the Naga Hills and the upper part of the Chindwin drainage system, and he concluded as follows:—"It is not impossible, therefore, that somewhere to the north there may be workable deposits of chromite associated with serpentine intrusions, and that such chromite deposits may prove to be the source of the platinum and platinoid metals occurring in the older gravels of the Upper Chindwin".[4]

Native copper and copper ores.

Native copper and copper sulphides have been obtained from the hills bordering the Kabaw valley in south eastern Manipur and the rocks surrounding this tract belong to the altered pre-Tertiaries and contain serpentine.[5] "In Burma", writes Dr. Morrow Campbell,

[1] R. D. Oldham : (52), p. 147.
[2] M. Stuart : (62), p. 252.
[3] F. R. Mallet : (46), p. 204.
[4] H. S. Bion : (3), p. 247.
[5] R. D. Oldham : (52), p. 25 ; V. Ball : (2), p. 278.

referring to the Pakokku Hill Tracts and Naga Hills, "considerable areas of serpentine occur in which native copper and chalcocite are associated with chromite. The conditions under which the copper ores occur lead to the belief that their formation was contemporaneous with serpentinization. Their deposition coincided with the period of ejection of the acid extract of the original peridotite. This acidic material is to be seen now in veins traversing the serpentine in the form of coarse quartz-hornblende pegmatite, and also chalcedonic quartz veins. At its periphery it is common to find a band of highly felspathic rock, evidently an acidic differentiate—the result of a previous leaching: the origin of this was evidently prior to that of serpentinization. This serpentine occurs in the midst of Cretaceous rocks, and beyond the periphery very numerous fissures in the sediments are filled with crystalline quartz. There is no granite or other igneous rock in the vicinity.[1] Dr. Morrow Campbell has kindly supplied the writer with some further notes on these interesting occurrences, from which it appears that while associated the chromite and copper minerals have no genetic connexion, the former being primary and residual in the strictest sense, whereas the copper seems to have been introduced into cracks in the serpentine, perhaps by deposition from the aqueous matter which brought about serpentinization. The native metal and the chalcocite are usually, if not always, in separate veins, and the former is invariably associated with cuprite (Cu_2O). This mineral is probably due to oxidation and purely secondary as are also the malachite, azurite and calamine ($ZnCO_3$) of the cracks of the ferruginous gossans.[2]

Serpentine outliers: the Tawmaw sub-Province.

Bion found that the serpentine belt crosses the Chindwin a few miles above the Kyaukse rapids, further than that it has not been traced continuously. In the Kachin hills however A. W. G. Bleeck has partially mapped four large serpentine masses which may or may not be in direct geographical connection with the belt. In one of these, which has a length of at least 20 miles and a maximum breadth of 15 miles occurs the intrusive jadeite-albite dyke in which the famous Tawmaw jadeite mines are situated. These have supplied the Chinese market with jadeite for centuries. Boulders of the mineral are common at certain places in this neighbourhood

[1] J. Morrow Campbell: (18), p. 14.
[2] J. Morrow Campbell: in a letter to the writer dated June 22nd, 1923.

in conglomerates of Miocene age. The serpentines are of a normal type, with olivine, when any still remains, altering into chrysolite, magnetite and chromite in crystals, grains, irregular concretions and veinlets.[1]

Other intrusive serpentines.

On the geological sketch map of the country north of Bhamo by C. L. Griesbach and F. Noetling, which illustrates the latter's account of the jadeite occurrences, twelve distinct and large intrusions are shown between Bhamo and Myitkyina, as "Jadeite and Basalt?", as well as two smaller ones in the vicinity of Tawmaw.[2] M. Stuart has indicated the presence of smaller ones still between Myitkyina and Putao.[3] Although these ultrabasic intrusives of the Irrawaddy valley proper lie outside the geographical limits of the main Arakan Naga Province, they are probably identical in age and origin with its intrusive serpentines.

THE PEGU GULF.

The Pegu Gulf is the name given by E. H. Pascoe to the Central tract of Burma lying between the foot-range of the Arakan Yoma on the west and the highlands of the Shan plateau and their southern prolongations on the east.[4] It may eventually prove to cover the little-known Tertiary deposits of the Hukong Valley which may be connected with those of Upper Assam through the Dihing basin and may, again, be disconnected from those of the Upper Chindwin.

Orography.

The Pegu Gulf contains the whole sequence of the Burmese Tertiaries ranging from the Lower Eocene through the Miocene and Oligocene to the Pliocene, a thickness of marine, estuarine, fluviatile and aeolian deposits totalling some 41,000 feet.[5] The gulf stretches some 600 miles from north to south and is, on an average, about 100 miles wide. It contains a great part of the present valleys of the Irrawaddy and Chindwin and also the valley of the Sittang, separated from that of the Irrawaddy by the low, north and south trending ridge of the Pegu Yoma which reaches from the Meiktila district to Pegu,

[1] A. W. G. Bleeck: (5), pp. 254-285.
[2] F. Noetling: (50), pp. 26-31.
[3] M. Stuart: (63), p. 247.
[4] E. H. Pascoe: (56), p. 23.
[5] G. de P. Cotter: (21), p. 415.

a distance of approximately 250 miles. The higher ground of the Pegu Yoma generally rises over 1,000 feet and but seldom crosses the 2,000 foot contour. From the sea coast, narrowing gradually towards the north, in typical deltaic fashion, the alluvium of the Irrawaddy rises very regularly but almost insensibly; nearer the sea the land is low and rarely above the high level of spring tides. The spurs from the Yomas and the ridges such as the Pondaung Range parallel to it, break the monotony of the lower ground further north. Owing to the manner in which the Arakan Yoma follows the Burmese Coast and prevents the moisture-laden winds of the south-west monsoon from reaching the districts to the east, there is an extraordinary variation in the climate of the Tertiary belt. In the south of the delta there is a mean annual rainfall of over 100 inches, diminishing to 25 inches per annum about latitude 21°, 250 miles away, and gradually increasing again further north. These conditions have a striking effect on the ecology of the riparian tracts of the Irrawaddy and tend still further to diversify the scenery.[1]

Geology.

It is impossible here to enter into details of the geology of the Pegu Gulf or to mention even briefly the work of all those who have participated in its elucidation. The foundations were laid by W. Theobald and have remained firm, with very little modification, up to the present time. The superstructure was raised by E. H. Pascoe in his monumental work on the oilfields of Burma[2] while the continuation of the geological mapping has been carried out by various officers of the Geological Survey of India. The systematic study of the fossil remains found in the Tertiary rocks was commenced by F. Noetling and carried on in a most detailed and critical manner by E. W. Vredenburg until his untimely death in 1923. G. de P. Cotter has described the Lamellibranchiata of a portion of the Eocene and has interpreted the geotectonics of the Gulf. L. Dudley Stamp has recently summarised the results of many previously published and scattered observations which tend to prove that :—

(*a*) the Tertiary succession is predominately marine in the north and mainly continental in the south.

[1] L. Dudley Stamp and Leslie Lord : " A Preliminary Note on the Ecology of Part of the Riverine Tract of Burma". (To appear shortly in the Journal, Asiatic Society of Bengal.)

[2] E. H. Pascoe: (56.)

(*b*) each horizon can be traced laterally from marine through deltaic into fluviatile or aeolian deposits as one proceeds northwards.

(*c*) there is on the whole, a tendency for continental conditions to move southwards as one ascends in the succession.[1]

It is now proved that the Irrawaddy basin was a subsiding geosyncline during the Tertiary period and while the Pegu Gulf was being slowly filled in by the sediments of one or more big rivers from the north, resulting in a gradual and general retreat of the sea to the south, there were periodic marine invasions from the south which have left their remains in wedge-shaped masses of marine deposits amongst rocks of genuine continental types. The effects of minor folding and buckling of the floor of the Gulf are sometimes found but are nowhere more apparent than around Shinmadaung near Pakokku, where a ridge of pre-Cambrian gneisses is overlain by Miocene rocks. The movements of uplift along the line of the Arakan Yomas and the accompanying subsidences of the floor of the Pegu Gulf itself culminated in the pronounced and widespread folding of Pliocene times.

The occurrences of petroleum on the Arakan Coast need not be considered here. They are of no great importance as far as is known at present and form part of the southern continuation of the oil-bearing belt of Assam. Yenangyaung the most productive oil-field of Burma, lies some two miles to the east of the Irrawaddy at Yenangyaung in the Magwe district. The oil-bearing strata form a symmetrical, elongated dome, about 6 miles long and 1 mile broad, but the producing area does not cover more than $1\frac{1}{2}$ square miles. Although the shallow oil sands of the Pegu rocks of this field have been worked by the Burmese from a remote antiquity, its modern exploitation dates only from 1887 when the Burmah Oil Co., Ltd. commenced drilling. Some of the wells are not over 3,000 feet in depth and the field keeps up a fairly steady output in the neighbourhood of 200 millions of gallons per annum.

Oil Fields of the Pegu Gulf.

The Singu oilfield, in the Myingyan district, lies further north but on the same bank of the Irrawaddy as Yenangyaung; it is really the southern prolongation of the anticlinal fold that has given rise

[1] L. Dudley Stamp: (50), pp. 441-501.

to the Yenangyat field. It was discovered by an officer of the Geological Survey of India in 1898 and it contains rich oil sands between the levels of 1,400 and 1,450, and 1,800 and 1,900 feet below the surface, while its output reaches over 100 millions of gallons per annum.

The Yenangyat oil-field has a length of 39 and a maximum width of 3½ miles, running for the greater part of its length as a steep scarp along the eastern bank of the Irrawaddy, in the Pakokku district. It forms a pronounced, asymetric anticlinal fold, the eastern limb of which is highly inclined, vertical or even inverted. Yenangyat began to produce in 1893 and obtained a maximum yield of over 22½ millions of gallons in 1903, but there has been a marked decline since then and the field now gives about 2½ millions of gallons per annum.

The upper Chindwin oil field has been prospected for some years and entered the list of productive fields in 1918 with an output of almost half a million gallons. This has increased to over 1 million gallons in 1921.

An acute anticlinal fold commences in the Pegu rocks, 2 miles to the north of Minbu and extends for several miles to the south-south-east. For a distance of 14 miles south of the town it is buried under alluvium but further south still, it appears as a broad arch which develops a subsidiary fold as one proceeds along its strike. Near Minbu itself there are mud volcanoes and gas pools but deep drilling has been somewhat disappointing for a number of reasons. Production commenced in 1910 with an output of 18,000 gallons, it attained a maximum of 4½ millions of gallons in 1918 which had fallen to about 3·75 millions of gallons in 1921.

The small oil field of Padaukbin lies on a flat-topped, asymetrical anticline, 3 miles north-west of Thayetmyo; it has yielded small quantities of oil for many years and is now being deep drilled. The small field of Yenanma is also in the Thayetmyo district. In addition to these producing oilfields petroleum is known to occur in seepages, gas pools and springs at many other places amongst the Tertiary rocks of the Pegu Gulf.

Coal in the Pegu Gulf.

Stuart has described coal seams in sandstones of Lower Tertiary age at Hlemauk, Kywezin and Posugyi in the Henzada district. Though seams up to 10 feet in thickness are known, the beds containing them are very contorted and faulted.[1] Thin seams of poor quality are also known to occur in the Kyaukpyu and Thayetmyo districts, again in Tertiary rocks[2] but they are of little value.[3] In the Pakokku district there are two small coal-bearing areas. In that of Letpanhla numerous seams are exposed and have been examined over 1½ miles. The main seam is from 5 to 6 feet thick but contains many bands of shales. There are three thin and variable seams of fair quality coal in the Tazu area but here again partings of shale are frequent. The economical value of these coals is very problematical. The seams in both cases occur in the lowest sub-division of the Pegu series and are of Miocene age.[4]

Coal-bearing rocks of Tertiary age have a wide extension in the valleys of the Nantahin, Peluswa, Maku and Telong streams, to the north of Kale, in the Chindwin valley, for a distance of 55 to 60 miles. The Nantahin-Peluswa tract covers an area of about 25 square miles, with a total thickness of coal of 48 feet. The field has not yet been developed though a few hundreds of tons of coal have been removed from a 10 foot seam exposed near Kale.[5] The thin and unimportant coal seams of Katha and Bhamo districts are also probably of Tertiary age.

Amber.

Small quantities of amber have been found in the Yenangyat oil field from time to time,[6] but the well-known, fluorescent, brown amber of Burma, which has been known to the Chinese for centuries comes from Maingkwan, an isolated village in the Hukong valley where the mines were first visited by the Europeans in 1836. The fossil gum occurs in irregular lumps in a blue clay, and it often contains the remains of insects entrapped in it as it exuded from its parent trees. A recent study of the insects has led to the belief that the amber is of Eocene age.[7] The connection of the Tertiary strata of the Hukong valley with the Pegu Gulf proper is obscure and will not be definitely known until the detailed geological survey of the upper Chindwin valley has been made.

[1] M. Stuart: (62), pp. 254-259.
[2] F. R. Mallet: (45), pp. 207-223.
[3] T. Oldham: (55), pp. 99-197.
[4] G. de P. Cotter: (20).
[5] E. J. Jones: (34), pp. 171-177.
[6] E. H. Pascoe: (56), p. 23.
[7] M. Stuart: (64), p. 404.

THE MOGOK-FRONTIER REGION.

In this group I include the gneisses, crystalline limestones and intrusive granites of Upper Burma and the northern part of the Burma-China frontier, separating from them in another group the highly metamorphosed sediments comprising the mica schists, phyllites, slates, quartzites, etc., which are known as the Monglong and Chaung Magyi Series in the Shan States and the Kao-liang Series in Yunnan.

Orography.

The rocks are typically developed in the Ruby Mines district of Upper Burma where their southern boundary is fairly well defined by the valley of the Nam-pai. To the north of this river they extend in a succession of parallel ranges from north-east to south-west which is also the strike trend of the rocks themselves. Proceeding northwards the crests rise from elevations of 2,000 to 3,500 feet to heights of 4,000 to 7,000 feet above the sea, until they reach 7,544 feet in Taung-me, immediately above Mogok.[1] The north and north-eastwards extensions of these rocks are still to be mapped in detail but they are known to be continuous with the gneisses of the country north of Bhamo, seen by Griesbach and Stuart and with the biotite gneisses and crystalline limestones of the frontier ranges between Bhamo and Tengyueh.[2]

In north-eastern Myitkyina Stuart found intrusive granite-gneiss with strips of crystalline limestone running north and south and penetrated by numerous veins of granite.[3] Griesbach noted a coarse, porphyritic gneiss characteristic of the eastern portion of the area he reported on accompanied by schistose, phyllitic and hornblendic varieties, the whole being extensively folded and crumpled and bearing seemingly conformable crystalline limestones in the flexures. Both Griesbach and Stuart seem to consider the crystalline limestones as metamorphosed Palæozoic rocks, a view which is not acceptable to the writer in the absence of further evidence. Writing of the Archæan sequence between the Ruby Mines and Yunnan, M. H. Loveman states that the gneiss is present in a great variety of types and often assumes both schistose and granitoid forms. All phases from extremely acidic to basic hornblende gneisses are found. This area of igneous and metamorphic rocks maintains a great

[1] T. H. D. LaTouche : (39), p. 33.
[2] C. L. Griesbach : (28), pp. 127-130 ; J. Coggin Brown : (9), pp. 173-205.
[3] M. Stuart : (64), p. 406.

regularity in its diversity, whether examined far to the south of Mandalay, (east of Pyawbwe) in latitude 24° 40[1], or in the north (at Teng-yüeh) in latitude 25°. The practical continuity of the bands of coarsely crystalline limestone in a well-defined zone, more than 250 miles in length is held by Loveman to be an almost conclusive proof of its original, organic origin.[1] In the Ruby Mines district the width of the gneissic belt is at least 40 miles, about the latitude of Mogok, and to the south it fills in the narrow strip between the Nampai and the Irrawaddy. In this area the strike is still north-west, but on the western bank of the Irrawaddy it turns due north and south and the Archæan rocks build the narrow range of hills which runs parallel to the river and terminates near Sagaing, opposite Mandalay. On the eastern bank of the Irrawaddy, the Palæozoic rocks come right down to the plains and the Archæan rocks are only to be seen in a few outlying hills rising abruptly from the alluvial carpet, but they re-appear again at Kyaukse, 25 miles south of Mandalay and beyond this point may form a more or less continuous band, from 12 miles and upwards in width, along the edge of the Southern Shan plateau Of the easily accessible regions of Burma, less is known of the rocks of this part than any other and we are hampered in an attempt to decide which of our regions it belongs to. How much of the band, which stretches almost to the sea in the vicinity of the mouth of the Sittang really belongs to the Archæan group, or what portion comprises later granitic intrusions, will not be known until the detailed survey of Burma has progressed considerably further than it has done to-day. East of Kyaukse P. N. Dutta found a group of old, metamorphosed sedimentary rocks, perhaps of Palæozoic age, intimately associated with and altered by intrusive granite.[2] C. S. Middlemiss found well-foliated micaceous and hornblendic gneisses, penetrated by syenite granites and pegmatites on his traverse from Thazi to Taunggyi,[3] and writes of the towering, sharp-edged ridges of the western boundary of the gneissic and metamorphic zone rising in a straight, unwavering line from the alluvial plains of the Meiktila, Yamethin and Toungoo districts. A. M. Heron in a personal communication to the writer states that while crossing from Tatkon, a few miles south of Yamethin to

[1] M. H. Loveman: (42), p. 108.
[2] H. H. Hayden: (30), p. 29.
[3] C. S. Middlemiss: (47), pp. 128-129.

Byingyi, a high granite peak overlooking the plains, he observed no gneisses or similar rocks. W. Theobald mapped the western margin of the crystallines in Toungoo and Pegu where they comprise his Martaban Group, and although he was inclined to regard most of them as gneisses he was puzzled by the manner in which "the schistose and crystalline characters of the beds are seen to give place insensibly to the granitoid habit." [1] It is noteworthy that no crystalline limestones of the Mogok variety have been reported from these southern regions. For our present purposes and in the absence of further knowledge we tentatively regard the Mogok-Frontier Province as ending about the latitude of Pyawbwe, or a short distance to the south of it, and the crystalline rocks of the regions further south as probably mainly intrusive granitic types belonging to our Tenasserim Province.

Characters of the gem-bearing limestones and associated rocks.

The gneisses and associated rocks of the Ruby Mines were studied by C. Barrington Brown and J. W. Judd.[2] The general mass consists of biotite gneisses, biotite-granulites and, more rarely, biotite schists. Hornblende is usually absent and garnet exceedingly common. Interfoliated with these intermediate types are other rocks of a more acidic nature, including very coarse pegmatites and graphic granites, aplites and granulites, granular quartzites and orthoclase-epidote rocks. The orthoclase frequently contains inclusions of fibrolite and is often converted into moonstone. In the Nyaungok district rubellite and indicolite often of fine gem quality occur in them. There are other subordinate basic and ultrabasic rocks, pyroxene gneisses and granulites with basic felspars related to anorthite in which a partial or complete transformation into scapolite is sometimes traceable. The ferro-magnesian silicates are represented by sahlite, diopside and aegirine, by bronzite, hypersthene and rarely by hornblende while garnets are frequent and abundant. The leading types are augite gneiss, enstatite gneiss, enstatite granulite, scapolite gneiss, pyroxenites, amphibolites and lapis-lazuli (lazurite-diopside-epidote rock). Many of these contain crystals of calcite scattered through them. The crystalline limestones which contain the rubies, sapphires and spinels are most intimately associated with the basic rocks and the passage from one into the other is of the most insensible kind. Some of the ruby-

[1] W. Theobald: (65), pp. 140-141.
[2] C. Barrington Brown and J. W. Judd: (7), p. 387.

bearing limestones are highly micaceous while others are calciphyres. With the gems, many oxides and silicates, both original and secondary, occur, and, in addition much graphite and pyrrhotite. Prof. Judd believed that the crystalline limestones were formed by purely chemical processes operating at great depths in the earth's crust, a view not accepted by LaTouche and other geologists, who think that they were originally components of a sedimentary series associated along a particular zone with rocks of igneous origin.

Graphite in the crystalline limestone.

Minute flakes of graphite are freely disseminated through the crystalline, ruby-bearing limestones, and in some places the mineral is concentrated into lenticular beds, developed along the line of contact of the limestones with scapolite gneiss. Attempts to mine this mineral, however, have not been successful.[1] The best known localities are at Wabyudaung and Kyaukgyi.

Ruby-bearing limestones of the Sagyin Hills and Myitkyina.

The ruby-bearing limestones crop out from the alluvium of the Irrawaddy valley in the Sagyin Hills, a few miles north of Mandalay, and some years ago rubies, sapphires and spinels were regularly obtained there ; later, however, the workings were closed. There are also areas in the Naniazeik neighbourhood of the Myitkyina district where the same gems have been found. Naniazeik itself is about 90 miles east-south-east of Tawmaw, the jade-mining centre. The precious stones used to be obtained from the detritus afforded by the disintegration of crystalline limestones surrounded by intrusive masses of granite.[2]

Gold in the Mogok Frontier Province.

According to J. M. Maclaren large, heavily mineralised but very low grade gold-quartz veins are reported to occur in the gneissic range lying south of the Shweli River in the Northern Shan States.[3]

THE CHAUNG MAGYI GROUP.

Distribution and Geology.

Herein are included both the mica schists of Mong-Long and the rocks of the Chaung Magyi Series. These rocks occupy the broad area of broken, hilly country which intervenes between the gneisses of the

[1] T. H. D. LaTouche: (40), p. 220.
[2] A. W. G. Bleeck: (4), pp. 164-170.
[3] J. M. Maclaren: (44), pp. 113-114.

Ruby Mines District and the Shan plateau. The mica schists spread across a somewhat restricted area in the State of Mong-Long and are nearly always of a biotitic nature. They are traversed everywhere by barren veins of milk-white quartz and along the boundary with the gneisses frequently have thick dykes of intrusive tourmaline granite. There is no sharp boundary between these mica schists and the phyllites, slates, greywackes and quartzites of the Chaung Magyi Series. The latter were consolidated, folded, dislocated and denuded before the earliest Palæozoic sediments were deposited upon them, and they are exposed in those places where the latter have been removed, as, for example, along the western edge of the plateau and amongst the hills to the north of the Gokteik gorge. They also appear along the eastern margin of the plateau in the ranges between it and the Salween as shown on the map, in the huge mass of Loi Ling and in the hills to the east of Mongyai, where they occupy the cores of elongated domes. Another detached area is found to the south of the plateau forming the mountain masses of Loi Pan (6,693 feet) and Loi Twang (5,752 feet), which like the other inliers rise as islands from the plateau surrounding them.

Great intrusions of granite, in which tourmaline is rare or absent, are found amongst these rocks in places. They occupy a large area around Nam Hsan, the capital of Tawng Peng, and occur on the northern side of Loi Pan and along the southern slopes of Loi Ling.

Gem Tourmaline in Mong-Long.

The gem tourmalines which used to come from Mong-Long were obtained from thick beds of gravelly detritus on the hill-slopes to the north of the the valley of Nampai, 2 or 3 miles north of town of Mong-Long and are believed to have been derived from the weathered products of several broad veins of the granite already described.[1] Perhaps the tourmaline mines of Maingnin, described by E. C. S. George, which are situated in the State of Mongmit to the north of the Ruby Mines are in a similar formation.[2]

Pyrites in the Chaung Magyi Series.

Several quartz veins carrying iron pyrites in large quantities occur at Hungwe in the Tawng Peng State,[3] in slates of this series.

[1] F. Noetling: (49), pp. 125-128.
[2] E. C. S. George: (26), pp. 233-238.
[3] H. H. Hayden: (31), p. 24.

Gold in the Chaung Magyi Series.

LaTouche has drawn attention to the small quantities of gold that are obtainable from many of the streams draining areas of rocks belonging to the Chaung Magyi Series. These have not proved to be of any great economic importance but sometimes support casual indigenous gold-washing efforts. Amongst others especial mention may be made of the gravels in the streams around Loi Sar in the Mong-Long State[1] and also of those in the streams which drain the northern slopes of Loi Twang, a mountain situated at the junction of the Mong Tung, Kehsi Mansam and Mong Kung States.[2]

THE MINGIN GROUP.

Orography.

The Mingin, or Maingthong, Hills stretch from north-north-east to south-south-west, between the valleys of the Mu and Meza rivers, both tributaries of the Irrawaddy, in the Katha district of Upper Burma, and attain their maximum breadth of 30 to 35 miles about latitude 24° 10′. It is difficult to decide with which region they should be classified or whether they should be grouped alone. As they form an isolated unit in the midst of unsurveyed areas, as the age of the rocks of which they are formed is quite unknown, and in some respects the characters of the rocks themselves are unique, it is most satisfactory to separate them entirely from the other regions as a single group. This action is perhaps justified by their metallogenetic sequence which is a gold-telluride one, entirely distinct from any other mineral association as yet discovered in Burma. The highest point in the southern portion of the range which is the only one that has been examined geologically is Maingthon Hill, 5,510 feet above sea level, but the peak of Taung-thon-lon, 5,621 feet, is perhaps in its northern continuation. The hills are buried in impenetrable jungle growing out of a thick carpet of vegetable mould which together place almost insuperable difficulties in the way of geological research.

Geology.

According to Noetling, eruptive rocks alone take part in the formation of the hills proper while the lower ground to the east, south and west of the eruptive mass consists of Miocene beds.[3]

[1] J. Coggin Brown: (8), pp. 37-51.
[2] T. H. D. LaTouche: (38), pp. 102-113.
[3] F. Noetling: (51), p. 116.

Quartz diorite forms the centre of the massif with numerous dykes of a different composition radiating from it while barren veins of white quartz also occur in it. The outskirts of the hilly tract are made of a hardened volcanic ash which in some places is studded with minute grains of magnetite, pyrites and pyrrhotite—the latter containing a trace of gold. Compact and altered agglomerates and fragments of amygdaloidal andesite are also found. Intruded into the volcanic ashes, which Noetling believed to be generically connected, are two types of dykes, the first closely related to the diorite in composition, the second consisting chiefly of felspathic quartz which contains a more or less considerable quantity of auriferous pyrites. Five localities are known on the eastern side of the hill tract where veins containing auriferous pyrites occur, and three others where the same mineral has been mined from volcanic ash by the Burmese. In the valley of the Nam Maw on the western side of the hills, an aphanite vein, intrusive into volcanic ash and about 4 feet thick, is composed principally of lath-shaped plagioclase crystals, hornblende and relics of augite with considerable quantities of granular magnetite. The cracks in this are filled with argentiferous cerrusite, which also forms thin layers encrusting the rock.[1]

Kyaukpazat Gold Mine.

One of the veins mentioned above was mined near Kyaukpazat between the years 1898 and 1903, when the pay shoot was lost and mining abandoned. According to J. M. Maclaren the country rocks are composed of consolidated and fairly well stratified tuffs and breccias of andesitic facies, intruded in places by quartz diorites. The vein itself averaged 3½ feet in width and was highly pyritic though of low grade. Its length was about 240 feet and below the 310 foot level of the mine the quartz was associated with calcite. It was occasionally clean but more often well mineralised, carrying five per cent. of chalcopyrite, pyrite, galena, franklinite and altaite, the rare telluride of lead.[2] Similar veins occur at Legyin, 11 miles further north and in the vicinity of Banmauk.

[1] F. Noetling : (51), p. 118.
[2] J. M. Maclaren : (44), p. 113 ; A. H. Bromley : (6), pp. 506-514 G. A. Stonier : (61), pp. 59-63.

THE SHAN-YUNNAN REGION.

Orography.

The Shan States of Burma form a broad triangle with its base on the Irrawaddy plains and its apex on the Mekong, but this is a political rather than a geological boundary, for the typical Palæozoic rocks of the Burmese Shan States extend far into the neighbouring province of Yunnan in Western China. Over the greater portion of the Northern States in Burma, the country possesses a Plateau-like character which begins in the north about latitude 23° and extends westwards and southwards where it narrows in on the borders of Mongnai and Mawkmai States about latitude 20° 20′. South of latitude 21° 45′ however the country has not been systematically geologically surveyed. On the west of the plateau the hills rise boldly from the Irrawaddy plains and soon reach heights of about 4,000 feet above the sea. Portions of the main plateau about the western edge have been let down by a series of step faults, of comparatively recent date, which trend north and south. Practically the whole of its surface is occupied by dolomites of Palæozoic age from which Devonian and Permo-Carboniferous fossils have been obtained in a few localities. On the north, it is bounded by an exceedingly broken, hilly region occupied by Silurian, Ordovician and Pre-Cambrian rocks which in their turn give place to the Archæan gneisses and crystalline limestones of Mogok and the adjacent areas. To the south and east of Hsipaw the country is very hilly, but beyond this again, the plateau extends from the Nam Tu river to the lofty peaks of Mong Tung in the south-east and the ranges bordering the Salween to Loi Ling (8,771 feet) in the east, and, with some breaks, to the north-east beyond Lashio. Nearly the whole area is drained by the Nam Tu, a tributary of the Irrawaddy, and its feeders, which often flow in narrow, profound gorges through the limestones. In the eastern limits of the States the Salween pursues its way southward to the sea in a deep, constricted valley, without receiving any tributaries of major importance. The plateau of the Northern Shan States to which all these remarks apply, has been aptly described as a country of gentle declivities and rounded interlacing hillocks, covered after the rainy season with a dense matting of elephant grass, interspersed in places with low scrub jungle and in others with park-like savannahs of scattered oak trees. The hills are often separated by narrow V-shaped valleys buried in dense jungle or sometimes clothed with pine forests. Viewed as a whole, the majority of the ridges commence with a north-west to south-east trend which bends more to the north and south, further to the south. The majority of these have heights of between 4,000 and 5,000 feet rising to peaks of 6,000 or 7,000 feet. The highest peak is that of Loi Ling in South Hsenwi which rises to 8,842 feet.

Geology.

The older Palæozoic rocks are best exposed along the fringes of the plateau, in the deep gorges where the covering of dolomite has been eroded through, or in the hill folds where it has been planed away. Mention must be made of the red clay which hides the surface of the plateau everywhere under a thick blanket and which sometimes contains important deposits of residual iron ores.[1] In numerous places there are flat basins of lacustrine and fluvio-lacustrine origin which are of Plio-Pleistocene age and often bear thick seams of lignite.[2] La Touche, from whose memoir most of these details are taken, is of the opinion that the area occupied by the gneisses and crystalline limestones was continuous with Gondwana land, that a great system of clastic rocks was accumulated as a result of its denudation in pre-Ordovician times, and, that towards the close of the end of this period of deposition, or during the interval of upheaval and disturbance that followed it, some exhibition of volcanic energy took place resulting in the emission of lavas and tuffs of an acid type, which are typically developed around Bawdwin. The oldest fossiliferous strata show great variations in thickness, contain no really coarse materials, and would appear to have been laid down in a shallow and tranquil sea which flowed over the remains of the folds of the older rocks, and derived its accumulations from a land surface near by and but little raised above sea level. The crystalline and metamorphic rocks with their extensions to the far north are believed to have constituted a prolongation of the Gondwana continent from the earliest ages. This separated the basin of the Tethys from the ancient Chinese ocean of which the Shan and Yunnan seas formed a part. Only in some such way is it possible to account for the marked differences between the pre-Carboniferous faunas of Yunnan and the Shan States on one hand and those of the Himalayas on the other. It is not necessary to suppose even

[1] J. Coggin Brown : (11), pp. 137-141 ; E. L. G. Clegg : (19), pp. 431 435.
[2] T. H. D. LaTouche and R. R. Simpson : (41), pp. 117-124 ; R. R. Simpson : (58), pp. 125 126 ; E. Moldenke : (48), pp. 30-31.

that the barrier was submerged in Permo-Carboniferous times, indeed, like the great mass of the Indian Peninsula it may never have been under the sea since the pre-Cambrian era. Omitting for the sake of brevity any allusion to the interesting but local palæogeographical details of the Shan States in the Silurian period, we find some evidence for the existence of an unconformity between the Silurian and Devonian rocks and a great deal more which leads us to conclude that the Plateau Limestone was deposited in a gradually deepening and widening sea which extended far into China, Siam and Indo-China. The Devonian fauna of Padaukpin in the Shan States possesses a purely European character but above this horizon there are Permo-Carboniferous limestones, both in the Shan States and in Yunnan, which carry a fauna exceedingly closely related to that of the Middle Productus limestones of the Punjab Salt Range and the Himalayas. After the formation of these limestones an elevation of the Shan-Yunnan province took place, the old sea bottom was not merely exposed but was worn into hills and hollows during the remainder of the Permian, and throughout the greater part of Triassic times. At the end of this period of emergence the surface of the limestone was again covered by the sea and the Rhætic shales and limestones accumulated. They are followed by the sediments of Jurassic age known as the Nam Yaw beds. No traces of any marine strata of later age have been found either in the Shan States or in Yunnan, where the sequence of main events was much the same, though there continental deposits date back to the Upper Permian and there are abundant remains of both marine and estuarine Triassic deposits.[1]

The final uplift of the plateau of the whole region in general, together with the more recent folding that it exhibits, are believed to correspond in great part with the movements that produced the Himalayas. Contemporaneous with these upheavals, indeed forming a connected part of the same events, was the uplift of the Indo-Malayan mountain chains further south.

Argentiferous galena and zinc blende deposits of Bawdwin.

The great silver-lead, zinc ore deposits of Bawdwin in the Northern Shan States are by far the most important in this particular ore province. They are connected with the Mandalay-Lashio section of the Burma Railways, by a narrow-gauge line, 50 miles

[1] J. Coggin Brown: (10), pp. 93-98; (14), pp. 55-59.

long, which meets the Burma Railways at Namyao, 547½ miles from Rangoon. European exploitation dates from 1902, but the upper parts of the deposits were mined for silver by the Chinese for centuries before that. The ore channel is at least 8,000 feet long and 400 to 500 feet wide and within this zone there are two ore bodies of major importance. The first, known as the "Chinaman," is a huge, lenticular replacement with a core of practically pure sulphides of lead and zinc. It is known to contain nearly 5 millions of tons of ore averaging 27·6 per cent. lead, 19 per cent. zinc, 0·5 per cent. copper and 25 ounces of silver per ton of lead. The ore body is not yet fully explored and this estimate does not include ore containing under 20 per cent. combined lead and zinc. The second ore body is known as the "Shan" and consists of a mixture of the sulphides of lead and zinc with larger quantities of copper than the "Chinaman" carries. A recent estimate of the proved and probable ore in the Shan body places the total at 570,000 tons, averaging 17 per cent. lead, 11 per cent. zinc, 6 per cent. copper and 19·3 ounces of silver per ton of lead.

These ore bodies have been formed by the metasomatic replacement of rhyolitic tuffs by sulphides carried in hot solutions which ascended from below through an intensely sheared and crushed zone. The tuffs form part of the Bawdwin Volcanic Series which is itself conformably overlain by the Pangyun Beds which may be of Ordovician or Cambrian Age. Five miles away from Bawdwin there is a great massif of intrusive biotite granite and it is thought possible that the mineralising solutions emanated from this. Unfortunately its age is not known. The age of the great Bawdwin overthrust fault which is mainly responsible for the shattering of the rocks in the vicinity of the ore body is the same as that of the Lilu overthrust with which it is connected further south. This does not appear to dislocate beds younger than the Silurian as far as is known at present, but which may be much younger.[1]

Lead-zinc Ore Bodies of Mohochaung.

About twenty-five miles to the north-east of Bawdwin are situated the old Chinese lead mines of Mohochaung of which unfortunately no full description has yet been published. M. H. Loveman, however, in a passing reference states that the ore bodies occur in sandstones and shales and are entirely similar

[1] J. Coggin Brown (12), pp. 121-178.

to those of Bawdwin as regards the character of the ore itself. The beds in which they are found are probably roughly contemporaneous in age with the Bawdwin sediments and although no rhyolite is present a coarse muscovite-biotite granite is found about 3 miles further to the west. Loveman concludes that "it is a reasonable presumption to consider the granite mass as extending below the ore bodies at both Mohochaung and Bawdwin probably at a great depth below the surface, and it may be to the influence of the granite that the mineralising solutions should be ascribed." This is, however, simply a hypothesis with no actual facts to support it.[1]

Other occurrences of lead and copper ores.

Small occurrences of galena and other lead and copper ores are known to occur in other parts of the Northern Shan States but none of them are of any economic importance. Amongst others the following may be mentioned:—the argentiferous galena which used to be mined from the Plateau Limestone near Lashio in the early days of lead slag smelting at Nam Tu[2]; the galena with cerussite from Namsaw, Hsipaw State; the galena scattered through grey limestone from Mong Tung. Chalcopyrite is known to occur in Mong Lung and stibnite in Hsumhsai.[3]

Argentiferous galena used to be mined from limestones of Ordovician age near Taunggaung about 20 miles to the north-east of Mandalay.

Near Maymyo, chalcocite occurs in the Plateau Limestone with smaller quantities of bornite and a little chalcopyrite, in tiny, reticulated veins disseminated through the mass of the limestone itself. It is often associated with barytes but the usual gangue is calcite. The copper-bearing beds are parallel to and in the vicinity of several galena veins which have been worked to a considerable extent by the Shans. Most of the galena occurs in irregular bunches though some of it is disseminated, and the tenor of both the lead sulphide and of the chalcocite in silver is high. For the details of this occurrence, I am indebted to Dr. J. Morrow Campbell.

Argentiferous Lead and Copper Ores of Bawzaing.

Bawzaing, or Mawson, is a small State of the Myelat division of the Southern Shan States which has been known to produce small quantities of lead and silver for many years. The workings were

[1] M. H. Loveman: (43), pp. 2120-2143.
[2] T. H. D. LaTouche: (39), p. 378.
[3] L. L. Fermor: (24), p. 234.

described by E. J. Jones in 1887 who states that they were situated at Bawzaing, Bwelou and Dwinzu, a few miles to the north and north-east of Kyauktat.[1] They were visited again by C. S. Middlemiss in 1899.[2] The ore is found beneath the surface covering of red clay overlying limestone, probably of Lower Palæozoic age; in yellow clay filling clefts and fissures in the limestone, and occurs in blocks and fragments varying from the size of a pea to masses three feet across.

A more extended examination of this area than was possible by either Jones or Middlemiss has been made recently by Dr. Morrow Campbell, who has found that the old Chinese pits cover a very wide expanse and that there are several bands of country which have been pitted over. They indicate that the deposits consist of very numerous veins parallel to one another and also crossing one another. The country rocks consist of limestones and shales while the stiff clays with which they are covered are believed to be of residual origin while the lumps of galena are the undissolved remains of the veins.

Pyrites near Bawzain and Kyauktat.

In the bed of the Thaingyi Chaung between Bawdwin and Pwehla, Jones records the occurrence of dark grey shales containing considerable quantities of nodular iron pyrites which was collected and distilled for sulphur. Similar occurrences exist in the Thinge Chaung and near Kyauktat. Middlemiss states too that pyrites is dug for the manufacture of sulphur at Yebok in the Pwehla State, and also at places in the Bawzaing State.

Copper ores of Bawzain, etc.

Jones records the occurrence of malachite at Kyauktat while Middlemiss mentions the presence of antimonial tetrahedrite with azurite and malachite, at a number of isolated places round about Yataung Hill, some 10 miles to the west-north-west of Bawzaing. At one place, Ganamgya, these ores occur in thin veins in limestone.

Galena at Mount Pima.

A vein of argentiferous galena, said to be from 3 to 30 feet thick, occurring in limestone among the foot-hills of Mount Pima, was opened up by a company in 1908. After the extraction of about 2,500 tons of ore in 1909, the mine was closed. It is regrettable that

[1] E. J. Jones: (35), pp. 191-194.
[2] C. S. Middlemiss: (47), p. 151.

there are no further mineralogical data of this occurrence which although so close to the Burmese plains must be regarded as properly within the Shan-Yunnan ore province.

Stibnite deposits of the Southern Shan States.

The stibnite deposits of the Southern Shan States were examined by H. C. Jones in 1917 who concluded that none of them appear to be large, or of much economic value.[1] They include the following localities :—Naking and Loi Hke in Mong Hsu, Mong Ing in Keng Tung, Hkomhpok and Loihsang in Mong Kung. The stibnite usually exists in a bladed, striated variety, and rarely in drusy and massive forms. The oxidised ores valentinite and cervantite are common. The Naking deposit, which in 1908 yielded about 1,000 tons of stibnite, is irregularly distributed through a vein in sandstones, perhaps of Jurassic age. Some of the others appear to be quartz-stibnite veins in Plateau Limestone.

Galena deposits of North-Eastern Putao.

Although lying well within the area which I have termed the Mogok-Frontier Province, the highly silicious limestones of the western side of the Nam Tamai valley may be an outlying patch of metamorphosed Palæozoic rocks belonging properly to the Shan-Yunnan Province. In them occur a number of sparse, disseminated galena-pyrites veinlets and impregnations which according to Stuart are not worth consideration from an economic point of view.[2]

Galena and Cupriferous pyrites of the Shweli-Nmai Hka divide in Myitkyina.

In much the same manner bands of sedimentary rocks consisting of limestones and shales appear to be isolated amongst the granites and true metamorphic rocks of the Frontier Ranges between Hpimaw and the Lagwi Pass. According to Stuart they seem to be identical in appearance with rocks of Ordovician and of Devonian age found by the writer in Western Yunnan. At the Chinese galena mines of this vicinity a fine-grained, silicified and chloritised tuff is in contact with white crystalline limestones which are believed to be altered Palæozoics, while the contact zone on both sides is veined and sparsely impregnated with galena, carrying small amounts of silver. Veins of slightly cupriferous pyrites are also found, frequently 10 feet and more across, which bear subsidiary veinlets of galena. Near the contact zone there is a peculiar calcite-mica-magnetite-pegmatite carrying occasional

[1] H. C. Jones : (36), pp. 44-50.
[2] M. Stuart : (63), pp. 241-254.

galena, pyrite and chalcopyrite. The deposits do not appear to be large and their altitude of over 11,000 feet above the sea in a most inaccessible locality, cursed with a climate which renders them only workable during the rains, detracts from their present commercial value.[1]

The abandoned galena mines of Ponsee in the Bhamo district which were described by Anderson in 1870 and the lead and copper mines of the Mingkuan district north of Têngyüeh in Yunnan, visited by the writer in 1907, the copper deposits of the Taungbalaung reserve in the south of Myitkyina and west of the 1st defile of the Irrawaddy, which produced small tonnages of ore in 1910 and 1911, perhaps form other examples of isolated portions of the Shan-Yunnan Province lying amongst older rocks.[2]

THE TENASSERIM REGION.

The Tenasserim region commences in the extreme south of Burma, in the Mergui district, and extends north through Tavoy, Amherst and Thaton, Papun and Karenni to the Southern Shan States where it ends somewhat indefinitely. It includes also parts of the eastern hilly portions of the Yamethin and Toungoo districts. It is characterised throughout by the presence of a biotite boss granite which forms the cores of the ranges of the Indo-Malayan system and with which the wolfram and cassiterite veins of Burma are intimately associated. It is but a part of the great mountain system which stretches into Western Siam and the Malay Peninsula. As delimited here it has a length of some 700 miles and a maximum breadth of about 60 miles as the crow flies, between the sea and the Siamese frontier in Tenasserim proper. The mountain ranges of the Southern Shan States coalesce into Karenni where elevations of over 5,000 feet are attained while further south they maintain a well marked individuality. The upper portion of the area is drained by the Salween and the lower by the Tavoy and Tenasserim rivers. These and the smaller streams usually follow approximately north and south courses. In the Amherst and Tavoy districts the higher peaks reach heights of over 4,000 and sometimes of almost 5,000 feet above the sea. In the south of Tavoy the massif of Myinmolet-

[1] **M. Stuart: (64), p. 408.**
[2] **J. Anderson: (1), p. 267; J. Coggin Brown: (12), pp. 128-131.**

khat is 6,800 feet high, but beyond this again, in Mergui, the elevations are lower and in the far south the 2,000 foot contour is not often crossed.

The geology of the region as a whole is only imperfectly known. The districts of Tavoy and Mergui have been surveyed in detail during the last few years, but for the rest we have to rely on the results of scattered traverses.

Geology.

The predominant rocks of the Tavoy district constitute an assemblage of highly folded and indurated sedimentaries to which the name Mergui Series has been given. They consist of crushed slates and argillites with greatly subordinate quartzites, limestones, agglomerates, and conglomerates, which are characterised by monotonous uniformity of type over great areas and across immense thicknesses of strata. In the Amherst and Mergui districts to the north and south of Tavoy respectively, Moulmein limestones of Permo-Carboniferous age are prevalent. The position of the Mergui Series in the geological scale is not settled. It is believed to underlie the Moulmein limestones, but as yet no junction sections have been found. Its general facies of vast thicknesses of uniformly argillaceous strata with subordinate limestones and quartzites is suggestive of the Dharwars, but the metamorphism of the Mergui Series is by no means so intense as that of this ancient system of India. It may prove eventually, however, that the Mergui Series is younger than this. In the Mergui district the series has the same characters as it possesses in Tavoy though it is perhaps somewhat more arenaceous. On some of the islands in the Mergui Archipelago indubitable volcanic rocks are found of both agglomeratic and hypabyssal types. In both districts there are areas of late Tertiary rocks of lacustrine and fluvio-lacustrine origin, sometimes carrying seams of lignite and beds of oil shale. The boss granites of Tavoy form six major intrusions some of which extend into the adjoining districts both north and south. Though it varies considerably in grain and texture, the granite is of an extraordinarily uniform composition wherever it has been examined in Tenasserim. It contains abundant quartz, both orthoclase and acid plagioclase, while the mica is usually biotite. Towards the peripheries of the intrusions where the rock becomes finer textured than the porphyritic and coarse-grained varieties nearer the centres, biotite becomes scarce or absent and muscovite takes its place. Hornblende is rare and accessory minerals are exceedingly scarce, Pseudo-foliation is sometimes developed near the contact as a result of fluxion in the partly consolidated magma, which has led some writers to mistake portions of the granite for gneisses. Veins of quartz, pegmatite and griesen are common in the granite and will be described later. Quartz-tourmaline pegmatites are also known but are much rarer. Owing to the absence of indications that it has been subjected to severe earth strains, it is believed by some that the granite did not participate as a solid rock in the great Himalayan compressive movements which uplifted the Indo-Malayan chain. It may have accompanied the upheaval but was not an older rock association fortuitously involved in it. But the question of the exact age of the granite must remain open until the geological survey of Northern Tenasserim has progressed further than it has at present.[1]

Geology of the Amherst District.

The Amherst district is largely a plains country but running through it with a general north-north-west-south-south-east trend are three continuous ranges, which converge in the south and join the mass of mountains where Amherst, Tavoy and Siam meet. The western range which is broken through by the Salween is a continuation of the Thaton range; it separates the coastal plain from the Ataran valley. The middle one is the divide between the Ataran and Haungthraw streams; the eastern is the Dawna range, between the Haungthraw and the Thaungyin, the latter stream being here the boundary between Burma and Siam. The Dawna range rises to over 5,000 feet in height, the other two, to about half that altitude.

The two outermost ranges are made up of slates, quartzitic sandstones, grits and impure limestones, very similar in all respects to the Mergui series of Tavoy and Mergui. In the broad valleys between the ridges are extensive developments of Moulmein limestone of Carboniferous age.[2] The Dawna range does not belong to the Tenasserim geological province for it is composed of coarse banded gneisses and schists with gneissose granites. One of the most characteristic rock types is a well banded, schistose, biotite gneiss into which a coarse tourmaline granite-pegmatite appears to be frequently intruded. The hills between the Dawna range

[1] J. Coggin Brown and A. M. Heron : (16), pp. 128-202.

[2] A. M. Heron : (32), pp. 37-38.

and the Siamese frontier are composed mainly of two formations, a limestone group and a red sandstone group: the former which forms the cores of the main ranges has been called the Kamawkala Limestone by G. de P. Cotter and is doubtfully regarded by him as of Triassic age. The red sandstones, resting unconformably on the limestones, are very similar in appearance to the red sandstones of Kalaw and like them may be of Jurassic age.

In the Yunzalin valley of the Salween district, E. L. G. Clegg recognised gneisses with intruded granites; an old series of altered sedimentaries corresponding to the pre-Cambrian of the Shan States and into which another granite is intruded and Plateau Limestone. It thus appears that in Tenasserim there are two different series of granitic rocks, one perhaps comparable with the early granites and gneisses of the Mogok-Frontier region, though crystalline limestones appear to be absent,[1] and the other which may for the time being be regarded as perhaps equivalent to the intrusive granites of Tavoy and Mergui and the Mong Long granites of the Northern Shan States. The late Tertiary basin of Htichara lies in the valley of the Mepale river between the Dawna range and the Choehko Taung.[2]

Ore Deposits of Tavoy.

Wolfram and cassiterite occur in Tavoy as segregation deposits in muscovite granite, in pegmatite veins with quartz, felspar, mica, fluorite, scheelite, molybdenite and sulphides of iron, copper and lead, the last being rare; in quartz veins with mica (practically always), fluorite (often), molybdenite (sometimes), pyrrhotite (in some cases), galena (rare), zinc blende (rare), arsenopyrite (rare), native bismuth (rare), bismuthinite (rare), and topaz (in one case only); in greisens with mica and pyrite. Wolfram and cassiterite occur in residual, detrital and talus deposits. Cassiterite occurs in alluvial and placer deposits. The tourmaline pegmatites of Tavoy do not carry metallic minerals and tourmaline is entirely absent from the wolfram and cassiterite veins of Tavoy, as far as is known. The veins themselves occur in the granite and in the sedimentary rocks not far from it, or in both. They were formed by the infilling of fissures; occur in parallel groups; often form series of overlap-

[1] It is to be noted however that sapphires and rubies have been reported from the Siamese frontier near Myawaddy. P. E. Jamieson: (33), p. 42.

[2] J. W. Gregory: (27), pp. 152-154; G. de P. Cotter: (22), pp. 279-296; L. L. Fermor: (25), pp. 53-55.

ping lenses, the individuals of which are often irregular, thin out and thicken again, split and re-unite, and possess clean walls. The alteration of granite walls to greisen is practically universal and the vein quartz is, as a rule, dense, very compact and milky white. There is every variation from great veins which have been traced for miles on the surface to insignificant ore-bearing stringers. Some of the veins bear traces of successive re-openings and the sulphide minerals are then largely secondary to wolfram and cassiterite. The general strike follows that of the main mountain trend and is north to south to north-west to south-east, though there are many exceptions to the rule. Dips are usually high. Molybdenite appears to have been the first mineral to have been formed. It was followed by wolfram, cassiterite, bismuth, bismuthinite and then the majority of the sulphides like pyrite, chalcopyrite, arsenopyrite, pyrrhotite, galena and blende. Pyrite belongs to several periods of the processes of mineral formation.

The output of wolfram concentrates in Burma rose from 1,688 tons in 1913 to 4,480 tons in 1917, and from the commencement of the war period to the end of 1918, no less than 17,642 tons, of which over 14,000 tons came from the Tavoy district alone, were exported. There were over 100 producing mines in 1918, the more important being Hermyingyi, Kanbauk, Widnes, Pagaye, Steel's Paungdaw, Taungpila and Kalonta. In all of these a certain amount of cassiterite occurs with the wolfram and the minerals are won both by underground and by hydraulic methods.

Mines of the Mergui District.

The chief wolfram deposits of the Mergui district are near Palauk in the north, and at Tagu near the Great Tenasserim River and about 70 miles from its mouth. The Palauk mines lie partly in granite and partly on Mergui sediments, but the producing veins are chiefly in the latter. The veins of the Tagu area are remarkable for their large size, varying from 3 to 15 feet in thickness. They are all in granite and carry arsenopyrite and chalcopyrite. The veins of the Maliwun mine in the extreme south of Mergui district are in granite, very close to its contact with sedimentary rocks. They bear muscovite, pyrite, chalcopyrite and arsenopyrite in addition to wolfram and cassiterite. Alluvial cassiterite workings are widely distributed over the Mergui district and perhaps the best known centres are Karathuri on the coast, Thabawleik on the

Little Tenasserim River, and the gravels of the Lenya and Pakchan rivers.[1]

Wolfram and Cassiterite in the Amherst District.

Tourmaline-muscovite pegmatites, locally carrying cassiterite but never wolfram, are common in parts of Mergui district.[2] It will be recalled that similar pegmatites in Tavoy carry neither of these minerals. Specimens of wolfram have been obtained from the vicinity of Ye close to the boundary of the Tavoy and Amherst districts, but no authentic details of the occurrences are available. Alluvial cassiterite has been worked in three localities as follows—Belugyun Island at the mouth of the Salween River and to the west and east respectively of the Seludaung range, which divides the coastal plain of the Amherst district from the valley of the Wingaw, a tributary of the Ataran. On Belugyun island argillaceous quartzites and grey slates are penetrated by coarse tourmaline-garnet-muscovite pegmatites, by tourmaline granite and drusy white quartz. Cassiterite has not been found *in situ* in any of these intrusive rocks though it is probably derived from one or more of them.

Wolfram and Cassiterite in Thaton.

The wolfram-bearing veins of Thaton are in two well-marked series, one in the granite and the other in the quartzitic sandstones of the long mountain ridge which runs parallel to the coast through this district. They differ markedly from those of Tavoy, for in them tourmaline is always present, with quartz, muscovite and probably felspar. In addition to wolfram they carry pyrite, chalcopyrite, arsenopyrite and molybdenite. Four parallel veins averaging only 4 inches in thickness have been traced for the unusually long distance of 2½ miles. The two areas which produced cassiterite in the Thaton district are at the extreme ends of the line of wolfram-bearing concessions. The northern one of Kadeik was purely an alluvial deposit, while the other consisted of a patch of eluvial ground in which the tin-ore was derived from small veins and stringers in the underlying sedimentary rocks.

Wolfram and Cassiterite in Bawlake State, Karenni.

The Mawchi mine is situated in the southern portion of the Bawlake State of Karenni. It possesses at least 10 important veins varying from 2½ to 5 feet in thickness. They are all in granite but the top of the hill in which they occur is occupied by limestone.

[1] J. Coggin Brown and A. M. Heron: (13), pp. 117-119.
[2] L. L. Fermor: (25), p. 52.

The vein quartz is drusy and carries cassiterite, wolfram, arsenical pyrites, pyrite, chalcopyrite and black tourmaline. Cassiterite and wolfram occur in intimate intergrowths and also separately.

Wolfram in the Yamethin District.

The wolfram-bearing area of the Yamethin district is situated close to the summit of Byingyi, a peak which rises 6,254 feet above the level of the sea, on the borders of the Yamethin district and Loi Long State in the Southern Shan States. Here, several thin veins occur in granite and carry wolfram, molybdenite and beryl.

Wolfram in the Southern Shan States, etc.

A few wolfram concessions have been taken up from time to time in Yengan, one of the most northerly of the States of the Myelat division of the Southern Shan States. In one of these, which lies 15 miles due east of Thedaw railway station, at mile 322 from Rangoon, in the direction of Mandalay there are two main granite exposures separated by a series of hardened sedimentary rocks, chiefly clay slates and white quartzites. Both groups of rocks are traversed by quartz veins, varying in thickness from a few inches to three feet. Close to the granite contact they contain wolfram but become barren further away. Molybdenite occurs in one part of the concession, and the oxidised compounds of copper and iron, which are found in the upper parts of the veins, appear to indicate the presence of sulphides of these metals below the zone of decomposition. Insignificant quantities of wolfram have been found in the Mawnang State and in the Sabedaung Forest reserve of the Kyaukse district. These occurrences mark the northern limit of the tin and tungsten bearing zone of Burma.[1]

Origin of the Wolfram and Cassiterite Veins.

The foregoing notes demonstrate that all the wolfram and cassiterite veins of Burma are closely associated with an intrusive granite, found throughout the Province from the vicinity of the Southern Shan States to the extreme limit of the Mergui district, forming the cores of the Indo-Malayan mountain ranges. It is believed that the ores were formed partially under conditions closely allied to strictly magmatic ones, were also produced by processes in which gaseous agencies, including compounds of fluorine, and sulphur, to some extent played a part, and, in rarer cases, by hydrothermal reactions which followed as a consequence

[1] J. Coggin Brown and A. M. Heron : (15), pp. 235-237.

of the former ones. The whole process of mineral vein formation associated with the great granite chain which extends through the Tenasserim ore province, appears to be a direct sequence of processes of differentiation or fractional crystallization, through a series of varying phases, induced in the original magma by decreasing temperature.[1]

Ores of Antimony and Lead in the Tenasserim Province.

It has already been shown how galena and more rarely stibnite occur sometimes as a late phase of the mineralisation which brought about the cassiterite and wolfram association of Lower Burma. Evidence is not wanting to show that in some cases at least these and other sulphides, such as pyrrhotite and chalcopyrite, accompanied a re-opening of the other vein fissures in which the tin oxide and the tungstates had already been formed, though it is not certain that this was always the case.

There still remain to be considered certain examples in which galena and antimonite occur in veins alone, and as these have not been studied in great detail or are situated in isolated districts of which the geological structure is still unravelled, their origin is still obscure, though in some cases there is reason to believe that they occur in rocks similar to the Moulmein limestones or to parts of the Plateau Limestone. They include the galena and cerrusite deposits of the Pagah range in the Amherst district and the lead and copper ores of the Yunzalin valley in the Salween district.

There are several references in the older literature to antimonite deposits scattered about the Amherst district, including one at Lekka Taung, about 23 miles south of Moulmein. Here, stibnite and cervantite occur in pockets in quartz veins (described as " a whitish quartzose sandstone, filling dykes or fissures ") traversing sandstone.

A narrow quartz vein containing stibnite has been traced for 600 or 700 feet in slates which presumably belong to the Mergui Series, and crop out along the crest of a low ridge, on the western slopes of the eastern of the two parallel ranges of the Thaton-Martaban hills, seven miles to the west of Katun railway station in the Thaton district.

A. M. Heron has described the antimonite deposit of Thabyu in the Amherst district.[2] It is situated in the extreme south-east,

[1] J. Coggin Brown and A. M. Heron : (16), p. 338.
[2] A. M. Heron : (32), pp. 34-43.

about 9 miles to the south of a police outpost of the same name on the Siam frontier. The veins themselves are very large, the biggest measured, which was followed for 600 feet, had an observed thickness of at least 20 feet. The stibnite occurs in bunches of radiating or parallel crystals up to 4 and 5 miles long, and in massive aggregates. Oxidation is pronounced and the massive sulphide has been converted to a depth of several inches to white, yellow and reddish, soft and earthy, antimony ochres, cervantite or stibiconite. The vein stuff is a yellow and white calcareous chert, showing distinct brecciation and often a cellular structure. Small angular fragments of slate occur in the veins which are believed to fill tension cracks and to have been deposited from water at a comparatively low temperature, and at a moderate depth from the surface. The veins are thus quite different in their character and origin from the wolfram and cassiterite-bearing veins of Lower Burma. The slates in which the veins are found are very uniform, black, fissile rocks similar to the argillites of the Mergui Series.[1]

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EXPLANATION OF PLATE.

PLATE 1.—Sketch map of the Ore Provinces of Burma. Scale 1″=64 miles.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1924 [August

THE MINERAL PRODUCTION OF INDIA DURING 1923. BY E. H. PASCOE, M.A., SC.D. (CANTAB.), D.SC. (LOND.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

CONTENTS.

INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these Records (Vol. XXXII) although admittedly not entirely satisfactory, is still the best that can be devised under present conditions. As the methods of collecting the returns become more precise and the machinery employed for the purpose more efficient, the number of minerals included in Class I—for which approximately trustworthy annual returns are available—increases, and it is hoped that the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will in time be reduced to a very small number. In the case of minerals still exploited chiefly by primitive Indian methods, and thus forming the basis of an industry carried on by a large number of persons, each working independently and on a very small scale, the collection of reliable statistics is impossible, but the total error from year to year is not improbably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

The average value of the Indian rupee during the year 1923 was 1*s.* $4\frac{9}{32}$*d.*; the highest value reached was 1*s.* $5\frac{1}{4}$*d.*, and the lowest 1*s.* $3\frac{15}{16}$*d.* The values shown in table 1 and all following tables of the present Review are given on the basis of 1*s.* 4*d.* to the rupee.

From table 1 it will be seen that there has been an apparent increase of over £1,200,000 or about 5 per cent. in the value of the total production over that of 1922. The value figures, however, are somewhat artificial. In some instances, although the output has fallen in quantity, it has increased in value; such increase does not necessarily give a true indication of the state of an industry.

The number of mineral concessions granted during the year amounted to 624 against 672 in the preceding year; of these one was an exploring license, 513 were prospecting licenses and 110 were mining leases.

TABLE 1.—*Total value of minerals for which returns of Production are available for the years 1922 and 1923.*

—	1922 (Rupee = 1*s.* 4*d.*)	1923 (Rupee = 1*s.* 4*d.*)	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal	9,755,343	9,738,569	..	16,774	—0·2
Petroleum	7,202,494	7,007,915	..	194,579	— 2·7
Manganese-ore(*a*)	915,428	2,215,984	1,300,556	..	+142·1
Gold	1,857,577	1,702,642	..	154,935	— 8·3
Carried over	19,730,842	20,665,110	1,300,556	366,288	+130·9

(*a*) f. o. b. value at Indian ports.

TABLE 1.—*Total value of minerals for which returns of Production are available for the years 1922 and 1923*—contd.

—	1922 (Rupee = 1*s.* 4*d.*)	1923 (Rupee = 1*s.* 4*d.*)	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Brought forward	19,730,842	20,665,110	1,300,556	366,288	+130·9
Lead and lead-ore	945,137	1,121,474	176,337	..	+18·7
Salt	744,966	749,382	4,416	..	+ 0·6
Silver	675,234	677,207	1,973	..	+ 0·3
Mica (*b*)	385,683	538,435	152,752	..	+39·6
Building materials	394,833	512,409	117,576	..	+29·7
Tin and tin-ore	188,963	185,641	..	3,322	— 1·8
Saltpetre	234,866	149,757	..	85,109	—36·2
Iron-ore	104,428	136,415	31,987	..	+30·6
Jadeite (*b*)	124,811	55,803	..	69,008	—41·6
Chromite	24,086	51,119	27,033	..	+112·2
Ruby, Sapphire and Spinel.	48,487	48,679	192	..	+ 0·4
Tungsten-ore	25,035	31,979	6,944	..	+27·7
Clays	16,900	21,356	4,456	..	+26·4
Magnesite	16,046	15,622	..	424	— 2·6
Zinc-ore (*b*)	90,505	11,584	..	78,921	—87·2
Phosphate	1,133	5,388	4,255	..	+375·6
Ochre	3,805	4,461	656	..	+17·2
Copper-ore	20,509	4,367	..	16,142	—78·7
Alum	6,651	4,298	..	2,353	—35·4
Fuller's earth	2,451	3,811	1,360	..	+55·9
Monazite	1,871	3,697	1,826	..	+97·6
Bauxite (*c*)	1,063	3,682	2,619	..	+246·4
Steatite	2,432	3,290	858	..	+35·3
Diamonds	6,110	3,100	..	3,010	—49·3
Barytes	3,200	2,850	..	350	—10·9
Ilmenite	1,200	2,100	900	..	+75·0
Soda	68	1,600	1,532	..	..
Zircon	1,280	1,160	..	120	—9·4
Gypsum	1,315	1,156	..	159	—12·1
Amber	131	915	784	..	..
Asbestos	701	659	..	42	— 6·0
Hyalite	..	352	352	..	..
	23,804,742	25,018,858	1,839,364	625,248	+ 4·8
			+1,214,116		

(*b*) Export values.
(*c*) Excludes the value of 932 tons.

II.—MINERALS OF GROUP I.

Chromite.	Iron.	Manganese.	Ruby, Sapphire and Spinel.	Silver.
Coal.	Jadeite.	Mica.	Salt.	Tin.
Copper.	Lead.	Monazite.	Saltpetre.	Tungsten.
Diamonds.	Magnesite.	Petroleum.		Zinc.
Gold.				

Chromite.

There was a very large increase in the production of Chromite which rose from about 22,800 tons in 1922 to over 54,200 tons in the year under review. This increase was mainly due to greater mining activity in the Mysore State.

TABLE 2.—*Quantity and value of Chromite produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.)		Quantity.	Value (Rupee=1s. 4d.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Baluchistan—						
Quetta-Pishin .	..	..	..	1,257	6,364	424
Zhob . . .	18,548	2,88,227	19,215	23,062	3,39,453	22,630
Bihar and Orissa—						
Singhbhum .	1,147	15,660	1,044	914	11,977	798
Mysore—						
Hassan . .	2,120	38,160	2,544	25,604	3,68,262	24,551
Mysore . .	962	19,240	1,283	3,405	40,735	2,716
Total .	*22,777*	*3,61,287*	*24,086*	54,242	*7,66,791*	*51,119*

Coal.

There was an increase during the year of some 646,800 tons, or about 3·4 per cent., in the output of coal. This increase was due chiefly to Bihar and Orissa and Bengal, but Hyderabad and Central India also contributed. The Central Provinces shewed a decrease of nearly 19 per cent., and the outputs from Assam and Baluchistan were also considerably reduced; the Punjab shewed a slight decrease. The increase in Bihar and Orissa was due to the two great fields of Jharia and Raniganj, to the recovery of the Giridih field and to the steady expansion of Bokaro. The maiden effort of the Talcher seams, which have been referred to in previous reviews, amounted to some 4,800 tons. The Sasti field of Hyderabad again shews a considerable decline which, however, is more than balanced by the partial recovery of the Singareni field. The Sohagpur field of Central India nearly doubled its production, but Umaria continued its decline. Ballarpur and the Pench valley were chiefly responsible for the serious drop in the Central Provinces output. The new Loi-an coalfield of Burma, which is of Gondwana and not of Tertiary age as formerly supposed, has made strides during the year and increased its output from 172 tons in 1922 to just over 2,000 tons in 1923.

The pit's mouth value of coal decreased in some areas and increased in others. In Burma it increased another 5 rupees or so, as it had done the previous year, and the rate in Baluchistan rose nearly Rs. 1-7-0. In the Punjab the drop in value amounted to Rs. 4-14-0, in the Central Provinces to Re. 1 and in Rajputana to Re. 0-4-5. Bengal and Bihar and Orissa both shew an average decrease, the presidency of Re. 0-8-4 and the province of Re. 0-1-10.

TABLE 3.—*Average Price (per ton) of Coal extracted from the mines in each province during the years 1922 and 1923.*

	1922.	1923.
	Rs. A. P.	Rs. A. P.
Assam	8 5 4	8 11 1
Baluchistan	13 7 5	14 14 4
Bengal	9 10 1	9 1 9
Bihar and Orissa	6 15 5	6 13 7
Burma	16 0 0	21 3 3
Central India	5 13 6	5 13 0
Central Provinces	7 10 7	6 10 7
Punjab	14 13 10	9 15 10
Rajputana	7 2 2	6 13 9

TABLE 4.—*Origin of Indian Coal raised during 1922 and 1923.*

——	Average of last five years.	1922.	1923.
	Tons.	Tons.	Tons.
Gondwana coalfields	19,490,848	18,520,513	19,218,284
Tertiary coalfields	434,487	490,473	439,494
Total	**19,925,335**	**19,010,986**	**19,657,778**

TABLE 5.—*Provincial Production of Coal during the years 1922 and 1923.*

Province.	1922.	1923.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam	348,103	326,149	..	21,954
Baluchistan	60,135	42,562	..	17,573
Bengal	4,328,986	4,621,578	292,592	..
Bihar and Orissa	12,711,328	13,212,250	500,922	..
Burma	172	2,166	1,994	..
Central India	161,231	175,950	14,719	..
Central Provinces	675,916	548,074	..	127,842
Hyderabad	642,880	658,429	15,549	..
Punjab	67,180	63,501	..	3,679
Rajputana	15,055	7,119	..	7,936
Total	**19,010,986**	**19,657,778**	**825,776**	**178,984**

TABLE 6.—*Output of the Gondwana Coalfields for the years 1922 and 1923.*

—	1922.		1923.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
Bengal, Bihar and Orissa—				
Bokaro	1,037,171	5·46	1,060,366	5·39
Daltonganj	31,933	0·17	11,815	0·06
Giridih	659,101	3·47	713,598	3·58
Jainti	96,612	0·51	82,166	0·42
Jharia	9,936,299	52·27	10,346,015	52·63
Rajmahal Hills	2,801	0·01	2,635	0·01
Ramgarh	4,565	0·02	4,197	0·02
Rampur (Raigarh-Hingir)	68,618	0·36	50,796	0·26
Raniganj	5,203,214	27·37	5,557,424	28·28
Talcher	..	..	4,816	0·02
Burma—				
Loi-an (Kalaw)	172	..	2,003	0·01
Central India—				
Sohagpur	42,693	0·22	80,125	0·41
Umaria	118,538	0·62	95,825	0·49
Central Provinces—				
Ballarpur	132,680	0·70	112,362	0·57
Mohpani	84,996	0·45	87,387	0·44
Pench Valley	453,484	2·39	346,094	1·76
Shahpur	1,069	0·01	2,063	0·01
Yeotmal	3,687	0·02	168	..
Hyderabad—				
Sasti	38,522	0·20	29,204	0·20
Singareni	604,358	3·18	629,225	3·21
Total	**18,520,513**	**97·43**	**19,218,284**	**97·77**

The yield of the Makum field of Assam decreased practically to its figure for 1921; both Baluchistan fields shewed heavy decreases also. Rajputana produced less than half what it did the previous year, and the total from the Punjab shews a decrease.

TABLE 7.—*Output of the Tertiary Coalfields for the years 1922 and 1923.*

—	1922.		1923.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
Assam—				
Khasi and Jaintia Hills	453	1·83	200	1·65
Makum	291,747		270,343	
Naga Hills	55,903		55,606	
Baluchistan—				
Kalat, Mach, Sor Range	26,269	0·31	16,058	0·22
Khost	33,866		26,504	
Burma—				
Kamapying (Mergui)	..	..	163	0·00
Punjab—				
Jhelum	47,832	0·35	43,253	0·32
Mianwali	14,301		11,965	
Shahpur	5,047		8,283	
Rajputana—				
Bikaner	15,055	0·08	7,119	0·04
Total	**490,473**	**2·57**	**439,494**	**2·23**

The export statistics shew an increase of nearly 59,500 tons, while the imports of coal and coke on the other hand fell to practically half what they totalled in 1922. Over two-fifths of the imports came from South Africa whose contribution increased by over 38,000 tons. Australia and "other countries" are the only other sources whose contributions shew an increase. From the United Kingdom imports fell from 718,500 to only 125,300 tons; from Japan India received a paltry 4,600 tons instead of 55,500 tons in the previous year.

TABLE 8.—*Exports of Indian Coal and Coke during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1*s.* 4*d.*).		Quantity.	Value (Rupee = 1*s.* 4*d.*).	
To—	Tons.	Rs.	£	Tons.	Rs.	£
Ceylon	76,466	10,24,893	68,326	119,616	20,19,641	134,643
Other Countries	13	543	36	16,943	3,21,744	21,449
TOTAL	76,479	10,25,436	68,362	136,559	23,41,385	156,092
Coke	632	36,997	2,466	16	575	38
Total of Coal and Coke	**77,111**	*10,62,433*	*70,828*	**136,575**	*23,41,960*	*156,130*

TABLE 9.—*Imports of Coal, Coke and Patent Fuel during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1*s.* 4*d.*).		Quantity.	Value (Rupee = 1*s.* 4*d.*).	
From—	Tons.	Rs.	£	Tons.	Rs.	£
Australia and New Zealand	17,849	6,57,330	43,822	59,380	21,61,940	144,129
Japan	55,547	21,21,080	141,405	4,660	1,64,274	10,952
Portuguese East Africa	157,122	57,74,455	384,964	115,942	31,10,309	207,354
Union of South Africa	231,548	72,07,760	480,517	269,777	69,31,688	462,113
United Kingdom	718,487	2,78,80,912	1,858,727	125,260	44,98,522	299,901
Other Countries	11,413	2,64,271	17,618	31,404	8,67,468	57,831
TOTAL	1,191,966	4,39,05,808	2,927,054	606,423	1,77,34,201	1,182,280
Coke	28,673	14,52,654	96,843	18,495	9,18,802	61,253
Patent Fuel	..	..	..	..	..	..
Total of Coal, Coke, etc.	**1,220,639**	*4,53,58,462*	*3,023,897*	**624,918**	*1,86,53,003*	*1,243,533*

The average number of persons employed daily in the coal-fields during the year remained practically the same as it was in 1922, while the average output per person employed shewed a slight improvement, rising from 94·6 tons in 1922 to 97·8 tons during the year under report; in 1919 this figure was 111·05 tons. The number of deaths by accident was unusually large, totalling 363, and corresponding to a death-rate of 1·81 per thousand persons employed; in 1922 the total figure was 243 corresponding to a rate of 1·21 per thousand.

TABLE 10.—*Average number of persons employed daily in the Indian Coalfields during 1922 and 1923.*

—	Number of persons employed daily.		Output per person employed.	Number of deaths by accident.	Death-rate per 1,000 persons employed.
	1922.	1923.			
Assam	3,636	3,901	83·6	13	3·3
Baluchistan	1,492	1,195	35·6	4	3·3
Bengal	44,893	44,251	104·4	73	1·6
Bihar and Orissa	119,790	123,554	106·9	211	1·7
Burma	65	197	10·9	..	..
Central India	2,595	2,762	63·7	1	0·4
Central Provinces	13,255	9,857	55·6	30	3·0
Hyderabad	13,402	13,558	48·6	28	2·1
Punjab	1,686	1,544	41·1	1	0·6
Rajputana	99	99	71·9	2	20·2
Total	**200,913**	**200,918**	..	363	..
Average	..	..	97·8	..	1·81

Copper.

Since 1919, following the commencement of smelting operations at the Rakha mines during the year 1918, the output of copper-ore in Singhbhum has been maintained with a fairly steady level till 1923. The decrease in the output of ore during that year was heavy, the amount totalling 6,500 tons only, valued at Rs. 65,500 (£4,367). This amount of the ore was obtained by the Cape Copper Company during the first quarter of the year, and from the 1st of April the works were closed down and pumping alone carried on. The amount of refined copper extracted from the ore amounted to 187·23 tons. The Rakha mines deposit is a low-grade sulphide ore containing two to four per cent. of copper, but a slightly improved grade of ore has recently been struck. Three other companies are prospecting in the Singhbhum belt, and one of these, the Cordoba Copper Company, has met with very promising ore-bodies in their Mosaboni mines. A zone of secondary enrichment, in which malachite and cuprite predominated, was pierced and an impoverished zone with practically no ore encountered beneath. The lode channel was, however, well defined, and beneath the impoverished zone chalcopyrite began to make its appearance in small lenses. At a vertical depth of 169 feet from the surface tunnels driven along the lode proved the presence of solid chalcopyrite, in some places 2 feet wide, over a considerable distance in length, and giving values varying between 10 per cent. and 25 per cent. of copper. Some very lucrative ore has been opened up by means of shafts sunk on this lode and there is every promise of an improvement in the outlook of copper production from this part of India.

The production of copper-ore in the State of Mysore during 1923 was *nil.*

Diamonds.

The output of diamonds from Central India amounted to 115·22 carats, valued at Rs. 46,495 (£3,100), as against 171·39 carats, valued at Rs. 91,648 (£6,110), in the preceding year.

Gold.

The total output of gold during the year under review fell to 422,306·56 oz. valued at £1,702,642. The increase shewn in the figures for 1922, which were 438,015·04 oz. valued at £1,857,577, was almost entirely a result of the treatment of accumulated cyanide slags; the amount of gold from these slags amounted to 3,172 oz. for that year, and during the year under review to over 1,000 oz.

TABLE 11.—*Quantity and value of Gold produced in India during the years 1922 and 1923.*

—	1922.			1923.			
	Quantity.	Value (Rupee = 1*s.*·4*d.*)		Quantity.	Value (Rupee = 1*s.*·4*d.*)		Labour.
	oz.	Rs.	£	oz.	Rs.	£	
Burma—							
Katha	12·01	815	54	23·46	1,672	111	42
Upper Chindwin	12	1,280	85	44·30	4,134	276	86
Madras—							
Anantapur	8,388 (*a*)	6,08,673	40,578	1,519 (*a*)	1,01,016	6,734	275
Mysore	429,559·6(*b*)	2,72,50,073	1,816,672	(*c*) 419,667·64	2,53,69,141	1,691,276	20,604
				1,001·46(*d*)	60,690	4,046	
Punjab	40·8	2,638	176	48·8	2,860	191	62
United Provinces	2·63	175	12	1·9	125	8	12
Total	**438,015·04**	*2,78,63,654*	*1,857,577*	**422,306·56**	*2,55,39,638*	1,702,642	21,081

(*a*) Fine gold.
(*b*) Contains 381,955·18 oz. fine gold including 3,172·24 oz. obtained from cyanide slags.
(*c*) Contains 381,058·93 oz. fine gold.
(*d*) Fine gold obtained from cyanide slags.

Iron.

The production of iron-ore increased by 28·6 per cent., *viz.*, from 625,274 tons in 1922 to 804,384 tons in 1923. The figure shown against Mayurbhanj in the following table represents the production by the Tata Iron and Steel Company Ltd.; although the raisings amounted to 507,225 tons, the total ore despatched from Mayurbhanj was 663,247 tons, the excess over production being taken from the balance of raisings in the year previous to 1922, which could not be despatched owing to the incompletion of railway sidings and consequently remained in stock. The production in Singhbhum is mostly that of the Bengal Iron Company, the Indian Iron and Steel Company being responsible for 9,909 tons from their mining at Gua. The Amda-Jamda railway extension to Gua has now been opened and the despatch of ore from that locality to the Indian Iron and Steel Company's blast furnaces at Hirapur commenced; previously these furnaces had been supplied with ore from Mayurbhanj State and the Central Provinces.

The Tata Iron and Steel Company produced 392,135 tons of pig iron, 151,097 tons of steel, including rails, and 3,506 tons of ferro-manganese, shewing a decided increase in each case over the previous year. The Bengal Iron Company produced 119,669 tons of pig iron and 41,849 tons of iron castings, also shewing substantial increases in the two cases. The Indian Iron and Steel Company commenced turning out pig iron, railway sleepers and railway "chairs" in November 1922; their production of pig iron during 1923 amounted to 77,980 tons.

TABLE 12.—*Quantity and value of Iron-ore produced in India during the years 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*)		Quantity.	Value (Rupee=1*s.* 4*d.*)	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Mayurbhanj . .	378,134	9,45,335	63,022	507,225	12,68,062	84,537
Sambalpur . .	798(*a*)	5,495	366	632(*a*)	4,427	295
Singhbhum . .	215,746	4,93,316	32,888	218,584	4,51,843	30,123
Burma—						
Mandalay . . .	..	..	..	329	1,316(*a*)	88
Northern Shan States .	27,680	1,10,720(*a*)	7,381	52,911	2,11,644(*a*)	14,110
Central Provinces . .	2,891	11,564	771	24,632	1,08,933	7,262
Other Provinces and States	25	(*b*)	..	71	(*b*)	..
Total .	**625,274**	*15,66,430*	*104,428*	**804,384**	*20,46,225*	*136,415*

(*a*) Estimated. (*b*) Not available.

In the Central Provinces the number of indigenous furnaces in operation fell from 148 in 1922 to 119 in 1923, the decrease being mainly in the Bilaspur district. The output of iron ore in Burma is by the Burma Corporation, Limited, and is used as a flux in lead-smelting.

Jadeite.

The output of jadeite in Burma, which in 1922 was more than double that of the previous year, fell to below the 1921 figure during the year under review. In other words the output of 7,724·7 cwts., valued at Rs. 8,69,340(£57,956) for 1922, fell to 3,626·6 cwts. valued at Rs. 8,20,120 (£54,675) during 1923. It will be noticed that although the quantity of jadeite extracted decreased so markedly, there was very little corresponding fall in the total value: this is due to the higher quality of jadeite met with.

The export figures, from which a better idea of the extent of the jadeite industry is obtainable, for the year 1922-23 were 5,762 cwts. valued at Rs. 18,72,168 (£124,811) sinking to 3,088 cwts. valued at Rs. 8,37,052 (£55,803).

Lead.

There was a further increase of about 74,000 tons in the production of lead-ore at the Bawdwin mines, and the total amount of metal extracted increased from 39,214 tons, valued at Rs. 1,41,71,392 (£944,759) in 1922 to 46,060 tons valued at Rs. 1,68,18,111 (£1,121,207) in 1923. The quantity of silver extracted rose from 4,205,584 oz. valued at Rs. 1,00,39,362 (£669,291) to 4,843,939 oz. valued at Rs. 1,01,16,985 (£674,466). The value of the lead extracted increased from Rs. 361 (£24·1) per ton in 1922 to Rs. 365 (£24·4) per ton in the year under review, and that of silver decreased from Rs. 2-6-2 (38·2*d.*) to Rs. 2-1-5 (33·4*d.*) per oz.

A new feature has developed during the opening up of the Shan Lode to the north. High grade silver-copper ore has been developed aggregating 335,681 tons, averaging 11·1 per cent. copper and 23 oz. silver per ton. Tetrahedrite has been found on No. 5 Level of the Shan Lode, assaying silver, 579 oz., lead, trace, zinc, 2·9 per cent., copper 26·5 per cent.

TABLE 13.—*Production of Lead and Silver Ore during 1922 and 1923.*

	1922.					1923.				
	QUANTITY.	VALUE (RUPEE=1*s.* 4*d.*)				QUANTITY.	VALUE (RUPEE=1*s.* 4*d.*)			
	Lead-ore.	Lead-ore and Lead.		Silver.		Lead-ore.	Lead-ore and lead.		Silver.	
	Tons.	Rs.	£	Rs.	£	Tons.	Rs.	£	Rs.	£
Burma—										
Northern Shan States	172,017	1,41,71,392(*a*)	944,759·5	1,00,39,362(*b*)	669,291	245,892	1,68,18,111(*c*)	1,121,207	1,01,16,985(*d*)	674,466
Southern Shan States	48·8	5,625	375	..	..	33	4,000	267	..	..
Central Provinces—										
Drug	1	36	2·4	..	..	..	..	..	..	..
Total .	172,066·8	*1,41,77,053*	*945,136·9*	*1,00,39,362*	*669,291*	245,925	*1,68,22,111*	*1,121,474*	*1,01,16,985*	*674,466*

(*a*) Value of 39,214 tons of lead extracted.
(*b*) Value of 4,205,584 oz. of silver extracted.
(*c*) Value of 46,060 tons of lead extracted.
(*d*) Value of 4,843,939 oz. of silver extracted.

Magnesite.

The revival of the magnesite industry in 1921 has maintained itself ever since. The figures for 1922, 19,273 tons valued at Rs. 2,40,692 (£16,046), have been exceeded slightly by those for 1923 which are 19,436 tons valued at Rs. 2,34,332 (£15,622).

TABLE 14.—*Quantity and value of Magnesite produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1*s*. 4*d*.)		Quantity.	Value (Rupee = 1*s*. 4*d*.)	
	Tons	Rs.	£	Tons	Rs.	£
Madras—						
Salem	18,417	2,21,004	14,734	19,336	2,32,032	15,469
Mysore	856	19,688	1,312	100	2,300	153
Total .	**19,273**	*2,40,692*	*16,046*	**19,436**	*2,34,332*	*15,622*

Manganese.

The output of manganese ore in India rose from 474,401 tons, valued at £915,428 f.o.b. at Indian ports, in the previous year, to 695,055 tons, valued at £2,215,984 f.o.b. Indian ports during 1923. The localities chiefly responsible for this increase were most of the areas in the Central Provinces, Vizagapatam and Sandur State in Madras, Shimoga in Mysore and Gangpur in Bihar and Orissa; each of the two fields of Bombay shewed an appreciable decrease. As in many other mineral industries that of manganese is apt to fluctuate with agricultural conditions. A good harvest will absorb the attention of labour and thus adversely affect the output of a mineral deposit; conversely mineral industries usually reap the benefit of a bad monsoon.

It will be noticed from tables 15 and 16, that the excess of exports over production which amounted to about 400,000 tons in 1922, has continued during 1923 to the extent of 155,000 tons, and is evidently a result of previous accumulation of stocks. The total exports from British Indian ports (table 17) increased by about 1,000 tons. The enormous increase of over 150,000 tons to the United Kingdom during 1922 has been repeated during 1923 to the extent of some 83,400 tons. France, America, Italy and Japan all took considerably more than they did in 1922, while Belgium, Holland and Germany absorbed less. In the case of Belgium, which transmits a portion of her imports to Germany, the decrease amounted to no less than 141,600 tons.

TABLE 15.—*Quantity and value of Manganese-ore produced in India during 1922 and 1923.*

—	1922.		1923.	
	Qantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b at Indian ports.
	Tons.	£	Tons.	£
Bihar and Orissa—				
Gangpur	16,372	32,062	20,439	67,619
Keonjhar	..	..	1,968	5,452
Singhbhum	..	..	46	152
Bombay—				
Chhota Udaipur	17,193	31,664	12,553	39,333
Panch Mahals	39,703	75,436	35,354	113,869
Central Provinces—				
Balaghat	169,182	331,315	224,746	743,535
Bhandara	41,143	80,572	79,949	264,498
Chhindwara	33,473	65,551	30,066	99,468
Jubbulpore	..	..	55	182
Nagpur	132,152	258,798	196,493	650,064
Madras—				
Bellary	..	..	2,429	6,255
Sandur State	1,470	1,458	37,318	75,413
Vizagapatam	7,845	9,349	22,524	52,650
*Mysore—**				
Chitaldrug	1,725	3,177	1,225	3,838
Mysore	..	..	1,200	3,760
Shimoga	14,018	25,816	28,377	88,915
Tumkur	125	230	313	981
Total	**474,401**	*915,428*	**695,055**	**2,215,984**

* The value figures are subject to revision.

TABLE 16.—*Exports of Manganese-ore during 1922 and 1923 according to Ports of Shipment.*

	1922.	1923.
	Tons.	Tons.
Bombay	389,442	386,255
Calcutta	371,708	375,340
Vizagapatam	13,710	14,275
Mormugao (Portuguese port)	87,917	74,454
Total	**862,777**	**850,324**

TABLE 17.—*Exports of Manganese-ore from British Indian ports during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 1s. 4d.)	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom	247,547	50,80,464	338,698	330,948	67,49,031	449,935
Germany	8,917	1,76,595	11,773	7,250	1,48,125	9,875
Netherlands	30,100	5,60,250	37,350	17,200	3,08,350	20,557
Belgium	299,656	70,66,054	471,070	158,013	38,67,943	257,863
France	150,665	33,79,202	225,280	173,057	35,91,847	239,457
Italy	11,700	2,95,650	19,710	19,862	5,88,397	39,226
Japan	1,351	36,714	2,448	5,657	1,39,038	9,269
United States of America	24,924	6,81,383	45,425	63,883	21,38,001	142,533
Total	774,860	*1,72,76,312*	*1,151,754*	775,870	*1,75,30,732*	*1,168,715*

Mica.

There was an increase of about 1,980 cwts. in the declared output of mica in 1923 above that of the previous year. As has been frequently pointed out, the output figures are incomplete, and a better idea of the size of the industry is obtained from the export figures. The exports of mica during 1923 amounted, in fact, to more than double the declared output, equalling 83,296 cwts., valued at Rs. 80,76,522 (£538,435) ; this figure is not far short of double that for the previous year 1922, which was 43,145 cwts., valued at Rs. 57,85,245 (£385,683). It will be noticed, however, that the average price of the mica fell from Rs. 134 (£8·9) to Rs. 97 (£6·5) per cwt.

TABLE 18.—*Quantity and value of the production of Mica in India recorded during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.)		Quantity.	Value (Rupee=1s. 4d.)	
	Cwts.	Rs.	£	Cwts.	Rs.	£
Bihar and Orissa—						
Gaya	15,975	1,40,803	9,387	2,949	1,10,785	7,386
Hazaribagh	13,420·8	9,08,680	60,579	20,849	10,65,166	71,011
Monghyr	5	90	6	15	525	35
Central Provinces	100	(*a*)	..	..	..	..
Madras—						
Nellore	1,246·2	89,254	5,950	8,671	3,14,703	20,980
Nilgiris	55	6,227	415	143	23,912	1,594
Mysore—						
Hassan	15·2	(*a*)	..	16	1,209	81
Mysore	120·5	(*a*)	..	(*b*)32·7	548	37
Rajputana—						
Ajmer-Merwara	632·4	41,992	2,799	539·3	52,880	3,525
Shahpura	308	15,658	1,044	640·2	18,217	1,214
Total	31,878·1	*12,02,704*	*80,180*	33,855·2	*15,87,945*	*1,05,863*

(*a*) Not available.
(*b*) Excludes 370·7 cwts. of raw mi a.

Monazite.

There was a recovery in the output of monazite in Travancore, which rose from 125 tons, valued at £1,871 in 1922 to 246·3 tons, valued at £3,697, in the year under review, but the amount is still very far short of the 1,260 tons obtained during 1921 and valued at nearly £31,000.

Petroleum.

The statistics of petroleum shew that it is becoming more and more difficult to maintain the output of India (including Burma) at the high level it reached in 1919 and 1921, which amounted to well over 305½ million gallons. During the year under consideration the total production amounted to nearly 294¼ million gallons against 298½ million gallons in 1922; for this decrease the two largest fields of Burma, Yenangyaung and Singu were mostly responsible.

The Yenangyat field is rapidly dying, and its yield is now less than that from Thayetmyo. As in the previous year the Singu and Yenangyaung oil-fields again shew a decided decrease, the outputs falling by 4⅗ million gallons and 4½ million gallons respectively. Thayetmyo and Badarpur contributed, to much the same extent in each case, to the general deficit; the latter field is a disappointment and shews no promise of making any substantial contribution to India's output of petroleum. Against these declines are to be recorded an increase in the Digboi field of over 2 million gallons and a gratifying increase of nearly 4½ million gallons in the Punjab. Minbu and the Upper Chindwin more or less maintained their level.

The utilization of the shallow oil-sands of the Yenangyaung field which were shut off during the competitive rush for the richer deep sands, continues; several remunerative wells are now being worked at depths a little above or below 400 feet. The electrification of this field has extended itself and more than 700 wells are now being either pumped or drilled, by electricity. The Indo-Burma Oilfields Ltd. have now ceased operations in the Yenangyaung field.

During the year active prospecting was continued in the Punjab, Assam and Burma, by a variety of oil interests.

In the Punjab the oil industry entered on a new phase with the completion at Rawalpindi, and the opening in February 1922, of the refinery erected by the Attock Oil Company to deal with the production of the Khaur oilfield in the Attock district. The refinery has a daily capacity of 65,000 gallons of crude oil, but the average throughput has not yet reached the maximum. The test wells in the Dhulian and Gabbir areas reached the depths of 2,800 feet and 1,760 feet respectively without striking oil in remunerative quantity; both wells have been abandoned but a fresh test at Dhulian has already been started.

TABLE 19.—*Quantity and value of Petroleum produced in India during 1922 and 1923.*

	1922.			1923.		
—	Quantity.	Value (Rupee = 1*s.* 4*d.*).		Quantity.	Value (Rupee = 1*s.* 4*d.*).	
	Gals.	Rs.	£	Gals.	Rs.	£
Assam—						
Badarpur . .	4,038,731	(*a*)6,66,794	44,453	3,555,377	4,01,912	26,794
Digboi . .	5,343,910	(*b*) 9,12,918	60,861	7,448,719	12,71,935	84,796
Burma—						
Akyab . .	8,886	2,563	171	8,628	2,573	172
Kyaukpyu . .	16,211	17,529	1,169	16,721	16,714	1,114
Minbu . .	3,940,416	12,31,380	82,092	3,915,140	12,23,481	81,565
Singu .	92,107,998	3,45,73,653	2,304,910	87,476,474	3,28,03,678	2,186,912
Thayetmyo. .	2,319,835	7,24,948	48,330	1,818,584	4,54,646	30,310
Upper Chindwin .	1,210,914	90,818	6,055	1,311,644	98,374	6,558
Yenangyat .	2,413,416	7,54,192	50,279	1,700,035	4,42,717	29,514
Yenangyaung .	179,741,493	6,72,22,038	4,481,469	175,158,721	6,54,51,455	4,363,430
Punjab—						
Attock . .	7,362,315	18,40,579	122,705	11,804,560	29,51,140	196,743
Mianwali . .	..	..	..	450	112	7
Total .	**298,504,125**	*10,80,37,412*	*7,202,494*	**294,215,053**	*10,51,18,737*	*7,007,915*

(*a*) Revised.
(*b*) Estimated at Rs. 0-2-8·8 per gallon.

The increase in the imports of kerosene oil reported during the previous year, continued to almost the same extent during the year under review, amounting to over 10 million gallons, the increase being shared by all countries concerned.

During 1923 the export of paraffin wax again decreased by over 3,000 tons.

TABLE 20.—*Imports of Kerosene Oil during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*).		Quantity.	Value (Rupee=1*s.* 4*d.*).	
	Gals.	Rs.	£	Gals.	Rs.	£
From—						
Borneo . .	7,245,454	36,75,965	245,064	10,045,993	52,69,607	351,307
Straits Settlements (including Labuan)	956,350	4,33,348	28,890	1,807,059	10,52,739	70,183
Sumatra .	..	..	..	1,678,770	8,65,615	57,708
United States of America.	43,088,869	3,22,16,428	2,147,762	45,477,974	3,14,97,214	2,099,814
Other Countries.	2,560,139	17,15,763	114,384	5,053,841	29,98,573	199,905
Total .	**53,850,812**	*3,80,41,504*	*2,536,100*	**64,063,637**	*4,16,83,748*	*2,778,917*

TABLE 21.—*Exports of Paraffin Wax from India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*).		Quantity.	Value (Rupee=1*s.* 4*d.*).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
Australia and New Zealand.	2,143	8,72,960	58,197	1,287	5,85,671	39,045
Belgium .	660	3,00,300	20,020	1,405	6,39,275	42,618
China . .	4,978	22,25,658	148,377	6,254	28,29,744	188,650
Italy . .	1,300	5,91,500	39,433	120	54,600	3,640
Japan . .	8,319	37,62,285	250,819	6,627	30,35,200	202,347
United Kingdom.	3,984	18,24,013	121,601	2,779	12,68,960	84,597
Union of South Africa.	2,264	10,30,574	68,705	1,745	7,93,100	52,873
United States of America.	1,250	5,68,750	37,917	1,104	5,02,447	33,497
Other Countries.	2,738	12,33,037	82,202	3,243	14,35,263	95,684
Total .	**27,636**	*1,24,09,077*	*827,271*	**24,564**	*1,11,44,260*	*742,951*

Ruby, Sapphire and Spinel.

There was a decrease in the output of the Mogok ruby mines in 1923, bringing the figure below what it was in 1921. The total weight, however, has little meaning in the case of precious stones, and in spite of the marked decrease in this figure, for which sapphires were mostly responsible, the value actually increased ; this is accounted for by the greater value of the rubies and the spinels.

TABLE 22.—*Quantity and value of Ruby, Sapphire and Spinel produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1*s*. 4*d*.).		Quantity.	Value (Rupee=1*s*. 4*d*.).	
	Carats.	Rs.	£	Carats.	Rs.	£
Burma . .	93,078 (Rubies)	6,45,304	43,020	92,592 (Rubies)	6,63,064	44,204
	102,462 (Sapphires)	76,045	5,070	65,692 (Sapphires)	59,207	3,947
	35,620 (Spinels)	5,963	397	28,726 (Spinels)	7,917	528
Total .	**231,160**	*7,27,312*	*48,487*	**187,010**	*7,30,188*	*48,679*

Salt.

There was again an increase in the production of salt during 1923 over that of the preceding year, amounting to over 127,000 tons, for which Bombay and Sind were more than responsible. The increase in Madras of some 20,000 tons was balanced by a deficit to the same approximate extent in Northern India. Aden shewed a fall of nearly 35,000 tons.

Against the above increase there was a severe deficit in the output of rock-salt, amounting to some 87,600 tons. The imports of salt remained very steady, shewing an increase of scarcely more than 1,600 tons.

TABLE 23.—*Quantity and value of Salt produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden . .	204,033	11,87,443	79,163	169,282	10,04,852	66,990
Bengal . .	3	106	7	..	..	..
Bombay and Sind.	450,558	27,18,435	181,229	613,150	34,41,843	229,456
Burma .	33,535	13,21,390 (a)	88,093	33,622	[6,99,000	46,600
Central India .	9·7	528	35	9·3	504	34
Gwalior * . .	210	10,007	667	22	1,061	71
Kashmir . .	..	..	..	0·6	100	6
Madras . .	465,929	29,43,066	196,204	485,569	30,70,226	204,682
Northern India .	499,386	29,81,926	198,795	479,295	30,13,046	200,870
Rajputana (Jaisalmer State).	234·5	11,596	773	206	10,103	673
Total .	**1,653,898·2**	*1,11,74,497*	*744,966*	**1,781,155·9**	*1,12,40,735*	*749,382*

* Figures relate to the official years 1922-23 and 1923-24.
(a) Revised.

TABLE 24.—*Quantity and value of Rock-salt produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Salt Range .	183,533	9,36,785	62,452	100,932	5,14,755	34,317
Kohat . .	18,904	56,444	3,763	14,640	46,744	3,116
Mandi . .	4,875	87,095	5,806	4,101	83,080	5,539
Total .	**207,312**	*10,80,324*	*72,021*	**119,673**	*6,44,579*	*42,972*

TABLE 25.—*Quantity and value of Salt imported into India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1*s.* 4*d.*).		Quantity.	Value (Rupee = 1*s.* 4*d.*).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
United Kingdom.	79,169	27,66,846	184,456	110,958	29,79,674	198,645
Germany .	49,301	15,33,763	102,251	35,720	9,86,386	65,759
Spain . .	55,165	15,91,597	106,107	45,579	13,40,659	89,377
Aden and Dependencies.	165,777	50,11,039	334,069	165,499	38,82,266	258,818
Egypt . .	106,647	31,35,660	209,044	76,143	18,47,153	123,143
Italian East Africa.	50,989	15,75,359	105,024	74,826	22,60,240	150,683
Other countries	25	2,794	186	15	2,325	155
Total .	**507,073**	*1,56,17,058*	*1,041,137*	**508,740**	*1,32,98,703*	*886,580*

Saltpetre.

There was a further decrease of over 3,000 tons in the total output of saltpetre. Bihar and the Punjab were mainly responsible for this decrease, where the outputs fell by 21 per cent. and 39 per cent. respectively. The total Indian production amounted to 8,555·4[1] tons valued at Rs. 22,46,355 (£149,757) against 11,672·9 tons valued at Rs. 35,22,995 (£234,866) in 1922. Exports also decreased from 11,000 tons in 1922 to 8,000 tons in the year under consideration, the decreases being shared by all the recipient countries except Mauritius and its Dependencies.

[1] It has been discovered that Calcutta and Madras have been producing saltpetre for some years past. The amount produced in Calcutta in 1923 was 22·6 tons, and in Madras 138·1 tons.

TABLE 26.—*Quantity and value of Saltpetre produced in India during the years 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar (refined) . .	2,009·1	5,05,494	33,700	1,622·9	3,86,243	25,749
Do. (*Kuthea*)	1,770	2,61,423	17,428	1,359·8	1,98,978	13,265
Central India .	15·8	3,780	252	18	4,030	269
Punjab . .	5,038·6	18,93,015	126,201	3,056·5	9,76,860	65,124
Rajputana .	182	46,487	3,099	...	...	...
United Provinces	2,657·4	8,12,796	54,186	2,498·2	6,80,244	45,350
Total .	**11,672·9**	*35,22,995*	*234,866*	**8,555·4**	*22,46,355*	*149,757*

TABLE 27.—*Distribution of Saltpetre exported during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
Ceylon . .	62,003	7,49,349	49,957	55,017	7,00,637	46,709
Hongkong .	51,591	12,60,460	84,031	25,949	5,68,629	37,909
Mauritius and Dependencies	26,225	4,59,461	30,631	47,109	8,35,998	55,733
Straits Settlements including Labuan.	8,132	2,09,019	13,934	5,216	1,17,337	7,823
United Kingdom.	50,898	7,42,310	49,487	17,313	2,92,309	19,487
United States of America.	4,362	61,438	4,096	...	...	...
Other countries	17,667	2,95,013	19,667	10,753	1,91,672	12,778
Total .	**220,878**	*37,77,050*	*251,803*	**161,357**	*27,06,582*	*180,439*

Silver.

There was a further increase in the output of silver from Bawdwin, amounting to some 638,350 oz. The production from the Kolar gold mines on the other hand amounted to half that of the previous year. The yield from the Anantapur gold mines fell from 554 oz. in 1922 to only 103 oz. in 1923. The total Indian production was 4,863,066 oz. valued at Rs. 1,01,58,102 (£677,207).

TABLE 28.—*Quantity and value of Silver produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Ozs.	Rs.	£	Ozs.	Rs.	£
Burma— Northern Shan States.	4,205,584	1,00,39,362	669,291	4,843,939	1,01,16,985	674,466
Madras— Anantapur .	554	1,231	82	103	202	13
Mysore— Kolar . .	38,166	87,911	5,861	19,024	40,915	2,728
Total .	**4,244,304**	*1,01,28,504*	*675,234*	**4,863,066**	*1,01,58,102*	*677,207*

Tin Ore.

There was again a small increase in the production of tin-ore amounting to 121 tons. The total production of 1,996 tons was derived from Burma, Tavoy contributing 73·8 per cent., and Mergu 25·9 per cent. No block tin seems to have been produced by Mergui. Imports of unwrought tin increased considerably from 34,459 cwts. in 1922 to 48,342 cwts. in 1923 ; 90·7 per cent. of these imports came from the Straits Settlements.

TABLE 29.—*Quantity and value of Tin and Tin-ore for the years 1922 and 1923.*

—	1922.						1923.					
	BLOCK TIN.			TIN-ORE.			BLOCK TIN.			TIN-ORE.		
	Quantity.	Value (Rupee=1*s*. 4*d*.).		Quantity.	Value (Rupee=1*s*. 4*d*.).		Quantity.	Value (Rupee=1*s*. 4*d*.).		Quantity.	Value (Rupee=1*s*. 4*d*.).	
	Tons.	Rs.	£	Tons.	Rs.	£	Tons.	Rs.	£	Tons.	Rs.	£
Burma—												
Amherst	..	..	..	11·8	16,339	1,089	..	..	..	3·2	2,002	133
Mergui	217·8	5,33,395	35,560	407·6	5,87,184	39,146	..	..	..	516·8	8,07,923	53,862
Tavoy	..	..	..	1,445	16,83,723	112,249	..	..	..	1,473	19,70,786	131,386
Thaton	..	..	..	10·3	13,790	919	..	..	..	3	3,900	260
Total	**217·8**	*5,33,395*	*35,560*	**1,874·7**	*23,01,041*	*153,403*	..	..	..	**1996·0**	*27,34,611*	*185,641*

TABLE 30.—*Imports of unwrought Tin (block, ingots, stabs) into India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1*s.* 4*d.*).		Quantity.	Value (Rupee = 1*s.* 4*d.*).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
From—						
United Kingdom.	3,242	3,90,077	26,005·1	3,755	5,09,977	33,998
Straits Settlements (including Labuan).	30,311	37,76,181	251,745·4	43,835	59,74,758	398,317
Other countries	906	1,09,461	7,297·4	752	1,06,887	7,126
Total .	**34,459**	*42,75,719*	*285,047·9*	**48,342**	*65,91,622*	*439,441*

Tungsten.

The production of wolfram decreased slightly from 943 tons valued at Rs. 3,75,532 (£25,035) during the previous year, to 872 tons valued at Rs. 4,79,693 (£31,979) in 1923. The decrease in output was, however, accompanied by a considerable increase in total value, amounting to £6,944. Practically the whole of the output was derived from the Tavoy district. Recent experiments have found a use for tungsten carbide as a substitute for the "bort" used in the crowns of core-drills. The carbide is said to have a hardness very little inferior to "bort," and to be cheaper. As the price of "bort" is between £10 and £12 a carat, the substitution of tungsten carbide may add a much needed impetus to the wolfram-mining industry.

TABLE 31.—*Quantity and value of Tungsten-ore produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*).		Quantity.	Value (Rupee=1*s.* 4*d.*).	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Mergui . .	4·75	4,274	285	0·2	52	3
Tavoy . .	938	3,71,048	24,736	871·8	4,79,641	31,976
Thaton . .	0·25	210	14	..	..	..
Total .	**943·00**	*3,75,532*	*25,035*	**872·0**	*4,79,693*	*31,979*

Zinc.

2,062 tons of zinc ore were exported during the year 1923 against 18,061 tons in the preceding year. The ore is found in association with galena in the Bawdwin mines leased by the Burma Corporation, Limited.

III.—MINERALS OF GROUP II.

Alum.

The production of alum in the Mianwali district of the Punjab decreased by 48 per cent. The output amounted to 3,456 cwts. valued at Rs. 64,472 (£4,298) in 1923 as against 6,632 cwts. valued at Rs. 99,760 (£6,651) in 1922.

Amber.

The production of amber in Burma rose from 3·6 cwts. valued at Rs. 1,960 (£131) in 1922 to 47·9 cwts. valued at Rs. 13,720 (£915) in the year under review.

Apatite.

An output of 1,082 tons of apatite was reported from the apatite magnetite deposits of Singhbhum; the value of the production was Rs. 10,820 (£721). There was also a production of 3,680 tons of "phosphate" valued at Rs. 70,000 (£4,667) from the Nandup area in Singhbhum, against 1,340 tons valued at Rs. 17,000 (£1,133) in 1922.

Asbestos.

The production of asbestos amounted to 247 tons valued at Rs. 9,880 (£659) in 1923 as against 242 tons valued at Rs. 10,520 (£701) in the preceding year. The whole output came from the Hassan district in Mysore State. There was no production from the Central Provinces.

Barytes.

Of the total production of 2,570 tons of barytes valued at Rs. 42,749 (£2,850), 1,603 tons valued at Rs. 22,749 (£1,517) were reported from the Karnul district of the Madras Presidency, and the balance, 967 tons valued at Rs. 20,000 (£1,333), from the Alwar State, Rajputana. The total output in 1922 amounted to 2,392·2 tons valued at Rs. 48,000 (£3,200).

Bauxite.

An output of 5,768 tons of bauxite valued at Rs. 54,065 (£3,604) was reported from Kaira in the Bombay Presidency. The Katni Cement and Industrial Company, Limited, extracted 779 tons of bauxite valued at Rs. 1,168 (£78) from the mines in the Jubbulpore district, Central Provinces. There was no production of bauxite in the Savantvadi State during the year 1923.

Building materials and Road-metal.

The total estimated value of building stone and road-metal produced in the year under consideration was Rs. 76,86,138 (£512,409), (see Table 32). Certain returns supplied in cubic feet have been converted into tons on the basis of certain assumed relations between volume and weight.

TABLE 32.—*Production of Building Materials and Road Metal in India during 1923.*

	Granite and Gneiss.		Laterite.		Lime.		Limestone and Kankar.		Marble.		Sandstone.		Slate.		Trap.		Miscellaneous.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Assam	2,648	429	3,886	606	..	..	121,983	18,363	..	..	1,967	231	..	..	..	..	81,475	8,460
Baluchistan	..	..	..	..	..	..	2	(a)	..	..	..	..	..	..	..	..	..	..
Bihar and Orissa	1,284	14	5,143	84	40,461	17,516	432,048	61,744	..	..	16,357	1,697	4,325	2,963	10,147	1,107	203,198	16,766
Bombay	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Burma	82,296	13,659	158,370	14,469	..	..	234,770	26,793	..	..	77,046	5,074	..	..	..	..	287,909	17,249
Central India	..	..	..	..	14,789	15,171	118,987	4,537	..	..	..	..	..	..	..	..	18	(a)
Central Provinces	..	..	..	..	..	..	259,986	35,429	..	..	..	..	..	..	..	..	..	..
Gwalior	..	..	..	..	..	..	1,971	443	..	..	11,637	4,616	..	..	..	..	..	..
Kashmir	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Madras	5,992	59	80,414	3,797	..	..	20,730	4,602	..	..	..	..	113	15	..	..	117,525	7,326
Mysore	..	..	3,548	512	7,824	1,689	9,915	2,229	..	..	5	1	..	..	..	..	52,383	2,929
N. W. F. Province	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5,155	325
Punjab	..	..	..	..	..	..	33,248	1,783	..	..	..	..	7,919	9,605	..	..	67,438	3,285
Rajputana	..	..	..	..	..	..	171,380	19,391	4,972	10,043	178,016	73,618	150	133	..	..	80,916	7,000
United Provinces	..	..	..	..	..	..	104,999	9,556	..	..	..	..	784	296	..	..	1,433,662	86,795
TOTAL	**92,220**	*14,161*	**251,317**	*19,468*	**63,074**	*34,376*	**1,510,019**	*184,870*	**4,972**	*10,043*	**285,028**	*85,237*	**13,291**	*13,012*	**10,147**	*1,107*	**2,329,679**	*150,135*

(The value in sterling pounds has been calculated on the basis of Rupee 1 = 1*s*. 4*d*.)
(*a*) Not available.

Clay.

The recorded production of clay rose from 102,755 tons, valued at Rs. 2,53,502 (£16,900) in 1922 to 148,112 tons valued at Rs. 3,20,333 (£21,356) in 1923.

TABLE 33.—*Production of Clays in India during 1923.*

——	Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs.	£
Bengal	38,396	62,952	4,197
Bihar and Orissa	7,953	1,28,904	8,594
Burma	34,871	40,767	2,718
Central India	386	670	45
Central Provinces	37,279	21,360	1,424
Delhi	3,676	3,908	261
Gwalior	536	7,326	488
Madras	110	200	13
Mysore	23,985	52,201	3,480
Rajputana	920	2,045	136
Total	**148,112**	*3,20,333*	*21,356*

Fuller's Earth.

There was a further and larger rise in the total production of Fuller's Earth, amounting to 27,696 tons valued at Rs. 57,168 (£3,811), against 13,550 tons valued at Rs. 36,764 (£2,451) in 1922.

TABLE 34.—*Production of Fuller's Earth during 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Central Provinces—						
Jubbulpore	152	748	50	80	393	26
Rajputana—						
Bikanir State	1,387	7,356	490	110	585	39
Jaisalmer State	11	100	7	6	90	6
Jodhpur State	12,000	28,560	1,904	27,500	56,100	3,740
Total	**13,550**	*36,764*	*2,451*	**27,696**	*57,168*	*3,811*

Gypsum.

The production of gypsum fell from 12,329·5 tons valued at Rs. 19,725 (£1,315) in 1922 to 10,280 tons valued at Rs. 17,351 (£1,156) in the year under review. The mineral hitherto reported from the Bikanir State in Rajputana as "sweet lime", the vernacular name for gypsum, has been found on examination to be deposited limestone, slightly tufaceous, with a little sulphate.

TABLE 35.—*Production of Gypsum during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Kashmir . .	73·5	500	33	(a)	304(b)	20
Punjab— Jhelum .	7,801	6,825	455	5,197	4,547	303
Rajputana— Jaisalmer .	55	400	27	83	500	33
Marwar .	4,400	12,000	800	5,000	12,000	800
Total .	**12,329·5**	*19,725*	*1,315*	**10,280**	*17,351*	*1,156*

(a) The output amounted to 1,880 cu. ft. The weight in tons is not available.
(b) Represents royalty paid to the State.

Hyalite.

An output of 12·5 cwts. of hyalite, a colourless variety of opal, valued at Rs. 5,282 (£352) was reported from Katha in Burma.

Ilmenite.

The output of ilmenite rose from 400 tons valued at £1,200 in 1922 to 700 tons valued at £2,100 in 1923.

Ochre.

The total production of ochre in 1923 amounted to 8,705·6 tons valued at Rs. 66,922 (£4,461), against 6,701·4 tons valued at Rs. 57,086 (£3,805) in the preceding year.

TABLE 36.—*Production of Ochre during the years 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*).		Quantity.	Value (Rupee=1*s.* 4*d.*).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa	400	10,400	693	441	11,078	733
Central India .	4,769·9	35,730	2,382	4,483·6	35,609	2,374
Central Provinces	697	5,139	343	2,449	8,495	566
Gwalior . .	832	5,720	381	895	6,265*	418
Kashmir . .	0·5	7	..	..	..	..
Madras . .	..	..	..	435	5,400	360
Rajputana .	2	90	6	2	75	5
Total .	**6,701·4**	*57,086*	*3,805*	**8,705·6**	*66,922*	*4,461*

* Estimated.

Soda.

There was a decrease in the production of soda in the Ladak tahsil, Kashmir, from 28 tons, valued at Rs. 1,021 (£68) in 1922 to about 7 tons, valued at Rs. 249 (£17) in the year under review. Salt consisting for the greater part of sodium carbonate, sodium bicarbonate and sodium chloride is obtained by evaporation from the waters of the Lonar Lake in the Buldana district of the Central Provinces. It is known under the general name of *trona* or *urao* for which there is no suitable equivalent in English. Its three chief varieties are *Dalla khar*, *Papadi* and *Bhooski*, according to the proportion of neutral carbonate; the first contains sodium chloride sometimes to the extent of 50 per cent. The total amount of *trona* or *urao* extracted in 1923 was 600 tons valued at Rs. 23,750 (£1,583).

Steatite.

There was a considerable rise in the production of steatite from 906 tons valued at Rs. 36,489 (£2,432) in 1922 to 2,257 tons valued at Rs. 49,353 (£3,290) in the year under consideration.

TABLE 37.—*Quantity and value of Steatite produced in India during the years 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*).		Quantity.	Value (Rupee=1*s.* 4*d.*).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Mayurbhanj .	71	6,900	460	65	6,000	400
Singhbhum .	0·55	31	2	76·8	4,424	295
Burma—						
Pakokku Hill-Tracts.	3·05	585	39	3·1	600	40
Central India—						
Bijawar . .	0·6	94	6	0·4	64	4
Central Provinces.						
Jubbulpore .	89·8	1,852	123	999	9,249	617
Madras—						
Nellore . .	70·4	3,969	265	77	4,417	294
Salem . .	542·6	14,298	953	890·2	20,947	1,396
Mysore . .	93·5	935	62	108	960	64
United Provinces						
Hamirpur .	27	7,425	495	34	2,500	167
Jhansi . .	8	400	27	4	192	13
Total .	906·50	*36,489*	*2,432*	2,257·5	*49,353*	*3,290*

Zircon.

The production of zircon in the Travancore State fell from 160 tons valued at £1,280 in 1922 to 145 tons valued at £1,160 in 1923.

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 38.—*Statement of Mineral Concessions granted during 1923.*

ASSAM.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cachar .	(1) The Burma Oil Co., Ltd.	Mineral Oil .	P. L. .	360	4th January 1923.	1 year.
Do. .	(2) Whitehall Petroleum Corporation, Ltd.	Crude petroleum and its associated hydro-carbons.	P. L. .	2,585·60	25th March 1923.	Do.
Garo hills	(3) Messrs. Gillander Arbuthnot & Co. on behalf of the Garo Hills Mining Syndicate.	Coal . . .	P. L. .	6,720	9th May 1922	Do.
	(4-9) Do. . .	Do. . .	P. L. . (renewal).	6,720 (consisting of six blocks).	Do. .	Do.
Lakhimpur	(10) The Assam Oil Co. .	Oil . . .	M. L. .	160	6th April 1923.	25 years.
Do. .	(11) Do. .	Do. . . .	P. L. .	4,160	20th April 1923.	1 year.
Do. .	(12) Do. .	Do. . . .	P. L. .	3,968	12th May 1923.	Do.
Do. .	(13) Do. . .	Do. . . .	P. L. .	4,480	7th April 1923.	Do.

BENGAL.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chittagong Hill Tracts.	(14) Messrs. Bulloch Bros.	Mineral oil . .	P. L. .	9,600	7th March 1923.	1 year.
Do. .	(15) Do. . .	Do. . .	P. L. .	7,719·04	Do. .	Do.
Do. .	(16) Do. . .	Do. . .	P. L. .	4,313·60	Do. .	Do.
Do. .	(17) Messrs. Whitehall Petroleum Corporation, Ltd.	Do. . .	P. L. .	8,857·60	14th April 1923.	Do.
Do. .	(18) Do. . .	Do. . .	P. L. .	6,400	Do. .	Do.
Do. .	(19) Messrs. Bulloch Bros. & Co.	Do. . .	P. L. . (renewal).	11,520	15th September 1923.	Do.
Do. .	(20) Do. . .	Do. . .	P. L. . (renewal).	24,960	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BIHAR AND ORISSA.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hazaribagh.	(21) Messrs. Nand Samont & Co.	Mica	M. L.	916	30th January 1923.	30 years.
Do.	(22) Messrs. F. F. Christien & Co., Ltd.	Do.	M. L.	40	1st September 1923.	Do.
Sambalpur	(23) Seth Puranmal Marwari.	Mica	P. L.	114·28	26th February 1923.	1 year.
Do.	(24) Diwan Bahadur Seth Ballabh Das, Manno Lal and Kanhiya Lal.	All minerals	P. L.	95·2	22nd December 1923.	Do.
Do.	(25) Seth Puranmal Marwari.	Mica	M. L.	57·86	Not yet executed.	30 years.
Santal Parganas.	(26) Bhudhar Chandra De.	Coal	M. L.	3·94	1st April 1923	2 years.
Do.	(27) Giris Chandra Mandal.	Do.	M. L.	0·93	Do.	Do.
Do.	(28) Jetha Mulji	Do.	M. L.	3	Do.	Do.
Do.	(29) Ramrekh Das Marwari.	Do.	M. L.	1·08	Do.	Do.
Do.	(30) Jetha Mulji	Do.	M. L.	5	Do.	Do.
Do.	(31) Bhudhar Chandra De and Giris Chandra Mandal.	Do.	M. L.	5	Do.	Do.
Do.	(32) Bhudhar Chandra De.	Do.	M. L.	4·27	Do.	Do.
Do.	(33) Ramrekh Das Marwari.	Do.	M. L.	1	Do.	Do.
Do.	(34) Binod Bihari De	Do.	M. L.	2·15	Do.	Do.
Do.	(35) Bansi Ram Marwari	Do.	M. L.	1·9	Do.	Do.
Do.	(36) Jamuna Prashad Marwari.	Do.	M. L.	5·04	Do.	Do.
Do.	(37) Ganga Ram Marwari.	Do.	M. L.	5	Do.	Do.
Do.	(38) Do.	Do.	M. L.	3·49	Do.	Do.
Do.	(39) Bhudhar Chandra De.	Do.	M. L.	1	Do.	Do.
Singhbhum.	(40) Babu Mangi Lal Marwari.	Manganese	M. L.	153·65	Lease not yet executed.	15 years.
Do.	(41) Kalicharan Trivedi.	Chromite	M. L.	730	Do.	20 years.
Do	(42) Rajani Kanta Pattadar.	Do.	M. L.	400	Do.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BOMBAY.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Belgaum .	(43) Mrs. T. C. Boyce .	Manganese ore .	M. L. .	320	1st June 1923	30 years.
Sukkur .	(44) Whitehall Petroleum Co., Ltd., Lahore.	Mineral oil and its associated hydro-carbons.	P. L. .	26,747·17	6th January 1923.	1 year.
Do. .	(45) Indo-Burma Petroleum Co., Ltd., Rangoon.	Mineral oil . .	P. L. (renewal).	6,008·21	21st March 1923.	Up to 31st August 1924.

BURMA.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab .	(46) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. .	4,800	19th January 1923.	1 year.
Do. .	(47) Do. . .	Do. . .	P. L. (renewal).	5,440	15th December 1922.	2 years.
Do. .	(48) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	3,620	16th July 1923.	1 year.
Do. .	(49) Messrs. The Whitehall Petroleum Corporation, Ltd.	Mineral oil and its associated hydrocarbons.	P. L. .	5,120	19th September 1923.	Do.
Amherst .	(50) Maung Tun-Maung.	Mineral oil . .	P. L. .	3,840	22nd March 1923.	Do.
Do. .	(51) Maung Ba Thet .	All minerals (except oil).	P. L. .	640	28th March 1923.	Do.
Do. .	(52) Maung Hte . .	Do. . .	P. L. .	640	22nd January 1923.	Do.
Do. .	(53) Mr. A. C. Jeewa	Do. . .	P. L. (renewal).	640	15th March 1923.	Do.
Do. .	(54) Mr. P. L. Peters .	Mineral oil . .	P. L. .	6,400	22nd May 1923.	Do.
Do. .	(55) Saw Eu Hoke .	All minerals (except oil).	P. L. .	510	9th April 1923	Do.
Do. .	(56) Dr. M. Shawloo .	Tin ore . .	M. L. .	640	29th May 1923.	30 years.
Do. .	(57) Maung Saw Maung and Ma Kywe.	All minerals (except oil).	P. L. (renewal).	640	21st March 1923.	1 year.
Do. .	(58) Mr. A. C. Jeewa .	Tin ore . .	M. L. .	640	28th August 1923.	30 years.
Do. .	(59) Mr. M. E. Moolla .	Oil shale . .	P. L. (renewal).	22,822·40	27th August 1923.	1 year.
Do. .	(60) Messrs. Balthazar and Son.	Mineral oil . .	P. L. .	5,760	19th November 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst .	(61) Mr. M. E. Moolla .	Mineral oil and oil shale.	P. L. .	15,520	Application sanctioned. License not yet executed.	2 years.
Do. .	(62) Messrs. E. Solomon & Sons.	Oil shale . .	P. L. .	12,800	Do. .	Do.
Do. .	(63) Maung Saw Maung and Ma Kywe.	Tin ore . .	M. L. .	601·60	18th December 1923.	30 years.
Bhamo .	(64) Messrs. The Tavoy Tin Syndicate, Ltd.	All minerals (except oil and precious stones).	M. L. .	3,232·62	15th September 1920.	Do.
Do. .	(65) Do. . .	All minerals (except mineral oil and jade).	P. L. (renewal).	3,328	4th June 1923	1 year.
Henzada .	(66) Mr. L. D'Attaides .	Mineral oil . .	P. L. .	640	13th January 1923.	Do.
Do. .	(67) Do. . .	Iron pyrite .	M. L. .	236·8	17th May 1923.	30 years.
Do. .	(68) Messrs. The Henzada Development Co., Ltd.	Coal . . .	P. L. .	4,640	18th October 1923.	1 year.
Katha .	(69) Ma Shwe Bwin .	All minerals (except oil).	P. L. .	640	23rd March 1923.	Do.
Do. .	(70) Ko Ko Gyi . .	Graphite . .	M. L. .	1,820	23rd February 1923.	30 years.
Do. .	(71) Ma Ma . . .	All minerals (except oil).	P. L. (renewal).	2	21st March 1922.	1 year.
Do. .	(72) Do. . .	Do. . .	P. L. (renewal).	1,600	1st September 1923.	Do.
Do. .	(73) Maung Shu Maung	Do. . .	P. L. (renewal).	960	7th December 1923.	Do.
Lower Chindwin.	(74) Maung Ya Hla .	Mineral oil . .	P. L. .	3,200	16th January 1923.	Do.
Do. .	(75) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L. .	5,241·60	30th April 1923.	Do.
Do. .	(76) Messrs. Balthazar & Son.	Do. . .	P. L. .	13,440	27th August 1923.	Do.
Do. .	(77) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	1,920	16th July 1923.	Do.
Do. .	(78) Do. . .	Do. . .	P. L. (renewal).	8,576	24th September 1923.	Do.
Do. .	(79) Do. . .	Do. . .	P. L. (renewal).	9,600	29th November 1923.	Do.
Do. .	(80) Ma Ma . .	Do. . .	P. L. (renewal).	910	14th December 1922.	Do.
Do. .	(81) Mr. M. L. Dawson .	Do. . .	P. L. (renewal).	3,008	30th November 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe .	(82) Mr. W. R. Smith .	Mineral oil .	P. L. .	1,920	27th February 1923.	1 year.
Do. .	(83) Hashim Esoof Malam	Do. . .	P. L. (renewal).	640	20th August 1922.	Do.
Do. .	(84) E. Solomon & Sons	Do. . .	P. L. (renewal).	640	14th July 1922.	Do.
Do. .	(85) Maung Maung Pe .	Do. . .	P. L. (renewal).	1,280	16th November 1922.	Do.
Do. .	(86) Mr. A. Rahman .	Do. . .	P. L. (renewal).	3,840	16th January 1923.	Do.
Do. .	(87) Jaffarally Tar Mahomed.	Do. . .	P. L. (renewal).	640	5th December 1922.	Do.
Do. .	(88) Maung Po San .	Do. . .	P. L. (renewal).	640	20th February 1923.	Do.
Do. .	(89) Mr. J. W. H. Fenner	Do. . .	P. L. .	2,560	26th April 1923.	Do.
Do. .	(90) Maung Po San .	Do. . .	P. L. .	2,560	6th May 1923	Do.
Do. .	(91) Messrs. The Union Oil Co.	Do. . .	P. L. .	3,840	15th June 1923.	Do.
Do. .	(92) Maung Po San .	Do. . .	P. L. .	760	13th June 1923.	Do.
Do. .	(93) Abdul Rahman .	Do. . .	M. L. .	640	4th May 1923	30 years.
Do. .	(94) Maung Mo Thaung	Do. . .	P. L. .	640	24th April 1923.	1 year.
Do. .	(95) Messrs. The Irrawaddy Petroleum Oil Syndicate.	Do. . .	P. L. (renewal).	1,920	12th March 1923.	2 years.
Do. .	(96) J. Tar Mahomed .	Do. . .	P. L. (renewal).	3,040	12th April 1923.	Do.
Do. .	(97) Maung Po Tun .	Do. . .	P. L. (renewal).	1,280	7th June 1923	Do.
Do. .	(98) Mr. E. E. Moolla .	Do. . .	P. L. (renewal).	100	13th June 1923.	Do.
Do. .	(99) Mr. A. Rahman .	Do. . .	P. L. (renewal).	1,200	23rd July 1923.	1 year.
Do. .	(100) Mr. A. E. Mayet .	Do. . .	P. L. (renewal).	1,040·30	29th September 1923.	Do.
Do. .	(101) Mr. E. E. Moolla .	Do. . .	P. L. (renewal).	100	1st August 1923.	Do.
Do. .	(102) Messrs. The Indo-Burma Petroleum Co.	Do. . .	P. L. (renewal).	7,680	25th August 1922.	2 years.
Do. .	(103) Mr. Abdul Rahman	Do. . .	P. L. (renewal).	1,440	6th August 1923.	1 year.
Do. .	(104) Do. .	Do. . .	P. L. (renewal).	3,200	25th August 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe	(105) Mr. E. Solomon	Mineral oil	P. L. (renewal).	640	17th August 1923.	2 years.
Do.	(106) Mr. Abdul Rahman	Do.	P. L. (renewal).	640	25th August 1923.	1 year.
Do	(107) Maung Po Aung	Do.	P. L. (renewal).	480	2nd October 1923.	Do.
Do.	(108) Maung Po Tun	Do.	P. L.	100	10th November 1923.	Do.
Do.	(109) Maung Ye	Do.	P. L.	640	Do	Do.
Do.	110) Mr. W. R. Smith	Do.	P. L.	626	25th October 1923.	Do.
Do.	(111) Mr. E. E. Moolla	Do.	P. L.	100	15th November 1923.	Do.
Do.	(112) Messrs. The Upper Burma Oil Syndicate.	Do.	P. L.	2,880	1st December 1923.	2 years.
Do.	(113) Maung Po San	Do.	P. L. (renewal).	640	20th February 1923.	1 year.
Do.	(114) Maung Kyan Baw	Do.	P. L. (renewal).	1,280	2nd March 1923.	2 years.
Do.	(115) Messrs. The Burma Oil Co.	Do.	P. L. (renewal).	1,200	12th September 1923.	Do.
Mandalay	(116) Messrs. Steel Bros. & Co., Ltd.	All minerals (except oil).	P. L. (renewal).	2,560	1st October 1922.	1 year.
Mergui	(117) Maung Choon	Tin and allied minerals.	P. L.	271·36	5th February 1923.	Do
Do.	(118) Md. Esoof Bhymeah	Tin	M. L.	317·44	6th January 1923.	30 years.
Do.	(119) Mr. C. Chan Shwe	Do.	M. L.	1,351·68	11th January 1923.	Do.
Do.	(120) Mr. D. D. Mukerji	Do.	P. L.	2,304	4th November 1922.	1 year.
Do.	(121) Mr. G. H. Hand	Tin and allied minerals.	P. L.	542·72	22nd July 1922.	Do.
Do.	(122) Mr. A.M.G. Forbes	Tin	P. L.	1,131·52	26th February 1923.	Do.
Do.	(123) Maung Kyin Bu	Do.	M. L.	424·96	27th January 1923.	30 years.
Do.	(124) Mr. Jas. McGregor	Tin and allied minerals.	P. L.	660·48	2nd January 1923.	1 year.
Do.	(125) Maung Po. Thaik	Tin	M. L.	491·52	23rd January 1923.	30 years.
Do.	(126) Maung Po	Tin and allied minerals.	M. L.	665·6	3rd March 1923.	Do.
Do.	(127) Mr. A. S. Mahomed.	Tin	P. L.	614	12th February 1923.	1 year.

P. L.=*Prospecting License*. M. L.=*Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(128) Mr. A. S. Mahomed	Tin . . .	M. L. .	256	20th January 1923.	10 years.
Do. .	(129) Maung Po . .	Tin and allied minerals.	M. L. .	266·24	31st January 1923.	30 years.
Do. .	(130) Maung San Dun .	Do. .	P. L. .	281·60	16th March 1923.	1 year.
Do. .	(131) Maung Choon .	Tin . . .	M. L. .	291·84	11th January 1923.	30 years.
Do. .	(132) Aung Sein Swai .	Tin and Wolfram.	M. L. .	1,418·24	20th February 1923.	Do.
Do. .	(133) Mr. T. Greenhow .	All minerals (except oil).	P. L. (renewal).	3,082·24	14th July 1921.	2 years.
Do. .	(134) Mr. V.A.R. Sutherland.	Cassiterite and gold.	P. L. (renewal).	640	21st July 1922.	1 year.
Do. .	(135) Maung San Dun .	Wolfram, tin and allied minerals.	P. L. (renewal).	1,120·0	26th October 1922.	Do.
Do. .	(136) Mr. Chan Khain Lock.	All minerals (except oil).	P. L. (renewal).	2,186·24	13th October 1922.	Do.
Do. .	(137) Messrs. The Burma Finance and Mining Co., Ltd.	Mineral oil and coal.	P. L. (renewal).	3,047·52	16th May 1921.	2 years.
Do. .	(138) Do. .	Do. .	P. L. (renewal).	2,329·60	Do.	Do.
Do. .	(139) Mr. A. C. Martin .	All minerals (except oil).	P. L. (renewal).	2,060·80	27th October 1922.	1 year.
Do. .	(140) Saw Lein Lee .	Tin and allied minerals.	P. L. (renewal).	640	2nd November 1922.	Do.
Do. .	(141) Mr. J. T. Doupe .	Tin . . .	P. L. (renewal).	1,075·20	8th December 1922.	Do.
Do. .	(142) Do. .	Do. .	P. L. (renewal).	1,287·68	Do. .	Do.
Do. .	(143) Mr. A. S. Mahomed.	Tin and allied minerals.	P. L. (renewal).	704	20th December 1922.	Do.
Do. .	(144) Messrs. Morgan and Holmes.	All minerals (except oil).	P. L. .	1,192·96	5th February 1923.	Do.
Do. .	(145) Mr. A. C. Campbell Rogers.	Tin . . .	P. L. .	1,126·40	9th January 1923.	Do.
Do. .	(146) Maung San Mae .	Do. . . .	P. L. .	1,123·36	16th June 1923.	Do.
Do. .	(147) Maung Pan On .	Do. . . .	M. L. .	216·22	20th March 1920.	30 years.
Do. .	(148) Lim Shain . .	Tin Ore .	M. L. .	450·56	22nd March 1923.	Do.
Do. .	(149) Charles Ellis .	Do. . .	M. L. .	734·72	17th April 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(150) Messrs. Wightman & Co.	All minerals (except oil).	M. L. .	4,899·24	9th March 1921.	30 years.
Do. .	(151) Mr. A. C. Campbell Rogers.	Do. .	P. L. . (renewal).	1,873·92	14th January 1922.	1 year.
Do. .	(152) Mr. J. T. Doupe .	Tin . . .	P. L. . (renewal).	640	18th August 1922.	Do.
Do. .	(153) Mr. Geo. W. Bowden.	All minerals (except oil).	P. L. . (renewal).	1,267·20	18th December 1922.	Do.
Do. .	(154) Mr. V. A. P. Sutherland.	Tin and allied minerals.	P. L. .	4,032	21st June 1923.	Do.
Do. .	(155) Mr. J. H. Leslie .	Tin Ore . .	M. L. .	494·86	26th February 1920.	30 years.
Do. .	(156) Mr. Joo Seng .	All minerals (except oil).	P. L. . (renewal).	1,172·48	28th April 1923.	1 year.
Do. .	(157) Mr. W. H. Olivant	Do. .	M. L. .	517·12	12th December 1923.	30 years.
Do. .	(158) Mr. T. Greenhow .	Tin . . .	M. L. .	245·76	14th March 1922.	Do.
Do. .	(159) Mr. S. O. Holmes	Coal . . .	P. L. .	2,201·80	30th November 1923.	1 year.
Do. .	(160) Mr. S. V. Norris .	Tin . . .	P. L. .	537·60	10th October 1923.	Do.
Do. .	(161) Maung San Dun .	Tin and allied minerals.	P. L. .	128	4th December 1923.	Do.
Do. .	(162) Mr. Joo Seng .	Tin Ore . .	P. L. .	35 840	3rd November 1923.	Do.
Do. .	(163) Mr. M. Haniff .	Do. . .	P. L. .	488·96	27th November 1923.	Do.
Do. .	(164) The Austral Malay Tin, Ltd.	Do. . .	P. L. .	2,135·14	1st December 1923.	Do.
Minbu .	(165) Messrs. The British Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. .	96·60	1st November 1922.	Do.
Do. .	(166) Do. .	Do. .	M. L. .	636	9th February 1923.	30 years.
Do. .	(167) Messrs. The Burma Finance and Mining Co., Ltd.	All minerals including mineral oil.	P. L. .	5,760	12th November 1922.	1 year.
Do. .	(168) Do. .	Do. .	P. L. .	4,160	14th November 1922.	Do.
Do. .	(169) Messrs. The Indo-Burma Oil-fields Ltd.	Mineral oil .	P. L. .	4,288	30th November 1922.	Do.
Do. .	(170) Messrs. The British Burma Petroleum Co., Ltd.	Do. .	P. L. .	1,926·85	5th January 1923.	Do.
Do. .	(171) Do. .	Do. .	M. L. .	556	28th February 1923.	30 years.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Minbu .	(172) Messrs. The Irrawaddy Petroleum Oil Syndicate.	Mineral oil .	P. L. (renewal).	2,376	16th July 1922.	2 years.
Do. .	(173) Mr. S. K. Osmany	Do. .	P. L. (renewal).	1,280	21st September 1922.	Do.
Do. .	(174) Mr. J. A. Tar Mahomed.	Do. .	P. L. .	4,568	21st November 1922.	1 year.
Do. .	(175) Maung Ba Thi .	Coal and mineral oil.	P. L. .	220	20th March 1923.	Do.
Do. .	(176) Maung U Kin .	Mineral oil . .	P. L. .	320	7th February 1923.	Do.
Do. .	(177) Do. .	Do. . .	P. L. .	160	Do.	Do.
Do. .	(178) Maung Po Khi .	Do. . .	P. L. .	435·60	24th January 1923.	Do.
Do. .	(179) Messrs. The Indo-Burma Oil-fields, Ltd.	Do. . .	P. L. .	223·6	13th February 1923.	Do.
Do. .	(180) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. (renewal).	640	23rd January 1923.	2 years.
Do. .	(181) D. M. Akhoon .	Do. . .	P. L. (renewal).	320	23rd December 1922.	Do.
Do. .	(182) Maung Po Khin .	Do. . .	P. L. .	1,900	21st February 1923.	1 year.
Do. .	(183) Maung Aung Ba .	Do. . .	P. L. .	2,920	17th May 1923.	Do.
Do. .	(184) Do. .	Do. . .	P. L. .	1,923	Do. .	Do.
Do. .	(185) Mr. D. M. Akhoon.	Do. . .	P. L. (renewal).	1,280	18th May 1923.	2 years.
Do. .	(186) Mr. Esmail E. Esmail.	Do. . .	P. L. .	320	5th October 1923.	1 year.
Do. .	(187) Messrs. The British Burma Petroleum Co., Ltd.	Do. . .	M. L. .	636	9th February 1923.	30 years.
Myingyan .	(188) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	1,580·16	20th December 1922.	1 year.
Do. .	(189) Maung Net and Maung So Min.	Do. . .	P. L. (renewal).	100	3rd November 1923.	Do.
Do. .	(190) Messrs. The Union Oil Co. of Burma.	Do. . .	P. L. .	6,720	17th September 1922.	Do.
Do. .	(191) Messrs. The Burma Oil Co.	Do. . .	P. L. .	2,813·44	22nd December 1922.	Do.
Do. .	192) Mr. Baijnath Singh	Do. . .	P. L. (renewal).	3,200	16th June 1923.	Do.
Do. .	(193) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. (renewal).	1,004·80	31st July 1923.	2 years.

P.L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Myingyan .	(194) Messrs. The Union Oil Co., Ltd.	Mineral Oil .	P. L. (renewal)	6,720	17th September 1923.	1 year.
Northern Shan States.	(195) Messrs. The Burma Corporation Ltd.	Iron Ore . .	P. L. .	640	1st October 1922.	Do.
Do.	(195) Do. .	Do. . .				
Do.	(197) Do. .	Do. . .	P. L. .	385	1st June 1922	Do.
Do.	(198) Messrs. The Coal-fields of Burma Ltd.	All minerals (except oil).	P. L. (renewal).	160	8th May 1923	Do.
Do.	(199) Messrs. The Burma Corporation Ltd.	Iron Ore . .	P. L. (renewal).	2,560	1st August 1922.	Do.
Do.	(200) Do. .	Do. . .	M. L. .	320	1st January 1920.	30 years.
Do.	(201) Do. .	Do. . .	M. L. .	320	Do. .	Do.
Do.	(202) Messrs. The Coal-fields of Burma Ltd.	All minerals (except oil).	P. L. (renewal).	385	1st June 1923	1 year.
Pakokku .	(203) Mr. Rowland Ady	Mineral oil . .	P. L. (renewal).	2,560	1st August 1923.	Do.
Do. .	(204) Mr. Colin Campbell	Do. . .	P. L. .	2,400	1st August 1922.	Do.
Do. .	(205) Ma Zan . .	Do. . .	P. L. .	554·4	22nd November 1922.	Do.
Do. .	(206) U Ba Oh . .	Do. . .	P. L. .	200 (in Blocks 92 and 97).	16th October 1922.	Do.
Do. .	(207) Maung Hmon and Maung Thin.	Do. . .	P. L. (renewal).	3,276·8	30th November 1922.	Do.
Do. .	(208) Do. .	Do. . .	P. L. (renewal).	320	31st August 1922.	Do.
Do. .	(209) Messrs. The Burma Oil Co.	Do. . .	P. L. (renewal).	100	Do. .	Do.
Do. .	(210) Mr. Ebrahim .	Do. . .	P. L. .	800	17th November 1922.	2 years.
Do. .	(211) Messrs. The Nath Singh Oil Co.	Do. . .	P. L. (renewal).	640	15th August 1923.	1 year.
Do. .	(212) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (renewal).	14,400	27th November 1921.	2 years.
Do. .	(213) Bajnath Singh .	Do. . .	P. L. (renewal).	800	4th February 1922.	Do.
Do. .	(214) Ma Zan . .	Do. . .	P. L. (renewal)	2,400	28th March 1922.	Do.
Do. .	(215) Messrs. The British Burma Petroleum Co., Ltd.	Do. . .	P. L. .	100	30th June 1922.	Do.
				640 acres in Block 138 of Yenangyat Oilfield.	15th August 1923.	1 year.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pakokku	(216) Maung Aung Ba	Mineral oil	P. L.		Applications sanctioned in November 1923. Licenses not yet executed.	
Do.	(217) Messrs. The Nath Singh Oil Co., Ltd.	Do.	P. L.			
Prome	(218) Maung Bo Ni	Do.	P. L. (renewal).	46·08	22nd December 1922.	1 year.
Do.	(219) Maung Aung Gyaw	Do.	P. L.	640	29th September 1923.	Do.
Do.	(220) G. Govindram	Do.	P. L. (renewal).	110·08	22nd February 1923.	Do.
Do.	(221) Maung Bo Ni	Do.	P. L. (renewal).	640	28th March 1923.	Do.
Do.	(222) Mr. Arthur Daires.	Do.	P. L.	8,320	10th October 1923.	Do.
Do.	(223) Ismail Aboo Ahmed	All minerals (except amber, jade and jadeite).	P. L.	4,441·60	18th December 1923.	Do.
Do.	(224) Messrs. Balthazar & Sons.	Mineral oil	P. L.	9,308·16	Do.	Do.
Do.	(225) Mr. Abdulla	All minerals (except amber, jade and jadeite).	P. L.	2,560	15th December 1923.	Do.
Do.	(226) Maung Aung Nyein	Mineral oil	M. L.	409·60	24th November 1923.	30 years.
Do.	(227) Maung Shwe Bwa.	Do.	P. L. (renewal).	640	25th May 1923.	1 year.
Shwebo	(228) Messrs. Frank Johnson Sons & Co., Ltd.	Do.	P. L.	5,036·80	9th May 1923	Do.
Do.	(229) Do.	Do.	P. L.	7,680	Do.	Do.
Do.	(230) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L.	2,560	23rd May 1923.	Do.
Do.	(231) Do.	Do.	P. L.	18,560	31st August 1923.	Do.
Do.	(232) Messrs. The Burma Oil Co., Ltd.	Do.	P. L.	4,518·40	25th September 1923.	Do.
Do.	(233) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L.	9,280	14th August 1923.	Do.
Do.	(234) Messrs. The Coalfields of Burma Ltd.	All minerals (except oil).	P. L. (renewal).	1,920	18th February 1923.	Do.
Do.	(235) Ismail Esoof Kaka	Coal	P. L.	1,920	23rd November 1923.	Do.
Southern Shan States.	(236) Mr. Lim Chin Tsong.	Lead	P. L. (renewal).	40	5th February 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan States.	(237) Capt. J. P. K. Wilkins.	All minerals (except oil).	P. L.	2·72	26th April 1923.	1 year.
Do.	(238) Sir J. G. Scott	Gold, Copper, etc.	P. L. (renewal).	5,440	9th May 1923	2 years.
Do.	(239) Do.	Do.	P. L. (renewal).	640	Do.	Do.
Do.	(240) Mr. R. B. Neville	All minerals (except oil).	P. L.	1,120	6th December 1923.	1 year.
Do.	(241) Messrs. Steel Bros.	Do.	P. L.	80	3rd December 1923.	Do.
Do.	(242) Do.	Do.	P. L.	224	Do.	Do.
Do.	(243) Mr. J. W. Ryan	Do.	P. L.	563·25	5th September 1923.	Do.
Do.	(244) Messrs. Steel Bros.	Do.	P. L.	2,500	27th November 1923.	Do.
Do.	(245) Do.	Do.	P. L.	2,370	15th October 1923.	Do.
Do.	(246) Do.	Do.	P. L. (renewal).	18,153	1st April 1923	2 years.
Tavoy	(247) Ong Hae Kyin	Wolfram and tin	M. L.	627	8th March 1923.	30 years.
Do.	(248) Messrs. The Indo-Burma Tin Corporation Ltd.	Do.	M. L.	3·90	17th March 1923.	Do.
Do.	(249) Do.	All minerals (except oil).	P. L.	144	30th January 1923.	1 year.
Do.	(250) Mr. M. T. Dunstan	Do.	P. L.	1,763·10	31st January 1923.	Do.
Do.	(251) Ma Yai	Tin and Wolfram	P. L.	305·92	20th January 1923.	Do.
Do.	(252) Mr. R. C. N. Twite.	Tin and allied minerals	P. L.	117	30th January 1923.	Do.
Do.	(253) Lee Taik Seong	Tin and Wolfram.	P. L.	293·68	10th January 1923.	Do.
Do.	(254) H. Kim Chu	Tin and allied minerals.	P. L.	579	19th February 1923.	Do.
Do.	(255) Mr. J. M. Manekji	Do.	P. L. (renewal).	1,106	27th October 1922.	Do.
Do.	(256) Mr. G. Lovell	Tin and Wolfram	P. L.	218	17th April 1923.	Do.
Do.	(257) Maung Maung	Do.	P. L.	640	25th May 1923	Do.
Do.	(258) Messrs. Tavoy Tin Syndicate, Ltd.	Tin and allied minerals.	M. L.	817·53	27th August 1920.	30 years.
Do.	(259) Quah Cheng Tock.	Wolfram, tin and allied minerals.	M. L.	657	18th April 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(260) Maung Po Swe	Wolfram and tin	M. L.	492	20th April 1923.	5 years.
Do.	(261) Maung Maung	Do.	M. L.	640	17th April 1923.	30 years.
Do.	(262) Mr. G. Lovell	Do.	P. L. (renewal).	123	13th January 1923.	1 year.
Do.	(263) Mr. J. J. A. Page	Do.	P. L. (renewal).	210	26th April 1923.	Do.
Do.	(264) Mr. M. T. Dunstan	Do.	P. L.	1,088	6th July 1923	Do.
Do.	(265) Mr. H. Kim Chu	Tin and allied minerals.	P. L.	390	21st September 1923.	Do.
Do.	(266) Mr. J. J. A. Page	Tin	P. L.	154	19th September 1923.	Do.
Do.	(267) Maung Ni Toe	All minerals (except oil).	P. L.	323	17th August 1923.	Do.
Do.	(268) Messrs. The Indo-Burma Tin Corporation Ltd.	Tin	P. L.	12·5	21st August 1923.	Do.
Do.	(269) Ong Hoe Kyin	Tin and Wolfram	P. L.	614	10th September 1923.	Do.
Do.	(270) Messrs. Steel Bros. & Co., Ltd.	All minerals (except oil).	M. L.	61·41	1st February 1919.	30 years.
Do.	(271) Md. Aslam Khan	Do.	M. L.	483	24th March 1919.	Do.
Do.	(272) Mr. G. Willison	Tin and Wolfram	P. L. (renewal).	640	5th May 1923	1½ years.
Do.	(273) Maung Ba Oh	All minerals (except oil).	P. L. (renewal).	632	23rd June 1923.	1 year.
Do.	(270) Maung Ni Toe	Do.	P. L. (renewal).	116	31st July 1923.	Do.
Do.	(275) Mr. M. T. Dunstan	Tin and Wolfram	P. L.	170	1st October 1923.	Do.
Do.	(276) Mr. A. Sheard	Tin and other minerals.	P. L.	1,280	30th November 1923.	Do.
Do.	(277) Do.	Do.	P. L.	1,920	Do.	Do.
Do.	(278) Do.	Do.	P. L.	1,920	Do.	Do.
Do.	(279) Mr. H. Kim Chu	Tin and allied minerals.	P. L.	637	18th December 1923.	Do.
Do.	(280) Maung Po Myee	All minerals (except oil).	P. L. (renewal).	570	18th June 1923.	Do.
Tharrawaddy.	(281) Maung Aung Nyun	Mineral oil	P. L.	640	22nd August 1923.	Do.
Thaton	(282) Maung Pu	Tin	P. L. (renewal).	505·6	2nd February 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thayetmyo .	(283) Mr. Ismail Abu .	Mineral oil . .	P. L. .	2,880	15th January 1923.	1 year.
Do. .	(284) Golabroy Govinda-ram.	Do. . .	P. L. .	640	8th December 1922.	Do
Do. .	(285) Do. .	Do. . .	P. L. .	640	Do. .	Do.
Do. .	(286) Ismail Abu Ahmed	Do. . .	P. L. .	2,240	15th January 1923.	Do.
Do. .	(287) Omar Abu Bucker	Do. . .	P. L. .	2,560	23rd February 1923.	Do.
Do. .	(288) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L. .	3,840	9th February 1923.	Do.
Do. .	(289) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Do. . .	M. L. .	320	8th March 1923.	30 years.
Do. .	(290) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L. .	524·8	8th February 1923.	1 year
Do. .	(291) Golabroy Govinda-ram.	Do. . .	P. L. .	3,200	8th December 1922.	Do.
Do. .	(292) Omar Abu Bucker	Do. . .	P. L. .	2,400	23rd March 1923.	Do.
Do. .	(293) Mr. Colin Campbell	Do. . .	P. L. .	2,995·20	16th January 1923.	Do.
Do. .	(294) Mr. Rowland Ady	Do. . .	P. L. .	3,008	13th January 1923.	Do.
Do. .	(295) Messrs. The Indo-Burma Oil-fields Ltd.	Do. . .	P. L. (renewal).	2,560	12th July 1922.	Do.
Do. .	(296) Do. .	Do. . .	P. L. (renewal).	4,800	6th October 1922.	Do.
Do. .	(297) Do. .	Do. . .	P. L. (renewal).	2,560	14th December 1922.	Do.
Do. .	(298) Do. .	Do. . .	P. L. (renewal).	6,386·4	23rd January 1923.	Do.
Do. .	(299) Ismail Aboo Ahmed	Do. . .	M. L. .	320	12th May 1923	30 years.
Do. .	(300) Mr. D. M. Akhoon.	Do. . .	P. L. .	640	2nd July 1923.	1 year.
Do. .	(301) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Do. . .	P. L. .	18,496	26th April 1923.	Do.
Do. .	(302) Yeo Eng Byan .	Do. . .	P. L. .	1,312	5th July 1923.	Do.
Do. .	(303) Mr. Colin Campbell	Do. . .	P. L. .	1,425	11th July 1923.	Do.
Do. .	(304) Ma Thein Yin .	Do. . .	P. L.	3,200	20th July 1923.	Do.
Do. .	(305) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Do. . .	P. L. (renewal).	11,840	12th March 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*concld.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thayetmyo	(306) Messrs. The Indo-Burma Oil-fields (1920), Ltd.	Mineral oil .	P. L. (renewal).	5,945·60	15th February 1923.	1 year.
Do. .	(307) Do.	Do. . .	P. L. (renewal).	2,560	12th July 1923.	Do.
Do. .	(308) Maung Hme Bu .	Do. . .	P. L. .	100	15th September 1923.	Do.
Do. .	(309) Golabroy Govindram.	Do. . .	P. L. .	100	20th September 1923.	Do.
Do. .	(310) Maung Hme Bu .	Do. . .	P. L. .	100	15th September 1923.	Do.
Do. .	(311) Messrs. The Indo-Burma Oilfields, Ltd.	Do. . .	P. L. .	5,235·20	3rd September 1923.	Do.
Do. .	(312) Chwa Maung Tike	Do. . .	P. L. .	100	12th October 1923.	Do.
Do. .	(313) Messrs. The Indo-Burma Oil fields (1920) Ltd.	Do. . .	P. L. .	30,720	Application sanctioned. License not yet executed.	2 years.
Do. .	(314) Messrs. The Union Oil Co., Ltd.	Do. . .	P. L. (renewal).	3,71·20	14th September 1923.	1 year.
Do. .	(315) Maung Tun Aung Gyaw.	Do. . .	P. L. (renewal).	60	20th September 1923.	Do.
Upper Chindwin.	(316) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	2,816	30th January 1923.	Do.
Do. .	(317) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (renewal).	12,800	12th September 1922.	Do.
Do. .	(318) Messrs. The Coal-fields of Burma, Ltd.	Coal . . .	P. L. (renewal).	2,188·8	31st August 1922.	Do.
Do. .	(319) Do.	Do. . . .	P. L. (renewal).	1,632	15th September 1922.	Do.
Do. .	(320) Do.	Do. . . .	P. L. (renewal).	10,284·8	20th November 1922.	Do.
Do. .	(321) Messrs. Frank Johnson Sons & Co., Ltd.	Mineral oil . .	P. L. (renewal).	3,078·40	26th October 1922.	Do.
Do. .	(322) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	1,760	28th August 1923.	Do.
Do. .	(323) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L. (renewal).	2,240	20th January 1923.	Do.
Do. .	(324) Messrs. The Coal-fields of Burma Ltd.	Mineral oil and coal.	P. L. (renewal).	3,264	Do.	Do.
Do. .	(325) Do.	Do.	P. L. (renewal).	7,584	14th January 1923.	Do.
Do. .	(326) Do.	Do.	P. L. (renewal).	1,824	7th February 1922.	2 years.
Do. .	(327) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal).	3,200	24th May 1921.	1 year.

P. L.=*Prospecting License* M. L.=*Mining Lease*

CENTRAL PROVINCES.

District	GRANTEE	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(328) The Indian Manganese Co., Ltd.	Manganese . .	M. L. .	15	30th January 1923.	20 years.
Do. .	(329) Messrs. B. N. Soparkar & Co.	Do. . .	M. L. .	19	23rd March 1923.	23 years, 9 months and 4 days.
Do. .	(330) Seth Permanand Saroopchand.	Do. . .	P. L. .	385	15th January 1923.	1 year.
Do. .	(331) Messrs. Ramprasad Laxmi Narayan.	Do. . .	P. L.	40	29th March 1923.	Do.
Do. .	(332) Central India Mining Co., Ltd.	Do. . .	M. L. .	1	29th January 1923.	2 years.
Do. .	(333) Messrs. B. P. Byramji & Co.	Do. . .	M. L. .	35	8th May 1923	15 years.
Do. .	(334) Do.	Do. . .	P. L. .	134	29th June 1923.	1 year.
Do. .	(335) Messrs. Lalbehari Narayandas and Ramcharan Shankerlal.	Do. . .	M. L. .	12	23rd March 1923.	15 years.
Do. .	(336) Messrs. Balkrishna Narayan & Co.	Do. . .	M. L. .	24	9th June 1923	30 years.
Do. .	(337) Do.	Do. . .	P. L. .	125	26th June 1923.	1 year.
Do. .	(338) Mr. C. S. Harris .	Do. . .	M. L. .	25	12th June 1923.	30 years.
Do. .	(339) Messrs. Ramprasad Laxmi Narayan.	Do. . .	P. L. .	36	18th June 1923.	1 year.
Do. .	(340) Mr. Sunderlal Golcha.	Do. . .	P. L. .	113	Do.	Do.
Do. .	(341) Rai Sahib Gowardhan Das.	Do. . .	P. L. .	71	26th June 1923.	Do.
Do. .	(342) Pandit Rewashanker	Do. . .	P. L. .	120	29th June 1923.	Do.
Do.	(343) Do.	Do. . .	M. L. .	18	27th June 1923.	10 years.
Do. .	(344) Messrs. Ramprasad Laxmi Narayan.	Do. . .	P. L. .	219	27th July 1923.	1 year.
Do. .	345) Pandit Kripashanker.	Do. . .	M. L.	48	12th July 1923.	15 years
Do. .	(346) Do.	Do. . .	P. L. .	181	20 th July 1923.	1 year.
Do. .	(347) Do.	Do. . .	M. L. .	57	1st August 1923.	15 years.
Do. .	(348) Messrs. Lalbehari Narayandas and Ramcharan Shankerlal.	Do. . .	P. L. .	25	20th July 1923.	1 year.
Do. .	(349) Do.	Do. . .	P. L. .	18	Do.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

Distict.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(350) Messrs. Balkrishna Narayan & Co.	Manganese .	P. L. .	43	24th July 1923.	1 year.
Do. .	(351) Mr. Balkrishna Narayan Soparker.	Do. . .	P. L. .	30	16th August 1923.	Do.
Do. .	(352) Pandit Rewashanker.	Do. . .	P. L. .	13	17th September 1923.	Do.
Do. .	(353) Messrs Bahmansha Fouzdar Bros.	Mica . . .	P. L. .	40	11th Septem- 1923.	Do.
Do. .	(354) Mr. Sunderlal Golcha.	Manganese . .	P. L. .	2	31st August 1923.	Do.
Do. .	(355) Rai Sahib Narayandas Khushaliram. .	Do. . .	P. L. .	13	20th July 1923	Do.
Do. .	(356) The Central India Mining Co.	Do. . .	P. L. .	12	31st August 1923.	Do.
Do. .	(357) Messrs. Martin & Co.	Do. . .	P. L. .	272	17th September 1923.	Do.
Do. .	(358) Rai Sahib Seth Gowardhandas.	Do. . .	P. L. .	52	3rd August 1923.	Do.
Do. .	(359) Seth Sarupchand .	Do. . .	P. L. .	17	21st October 1923.	Do.
Do. .	(360) Do. .	Do. . .	P. L. .	70	25th October 1923.	Do.
Do. .	(361) Pandit Rewashanker.	Do. .	M. L. .	45	16th October 1923.	10 years.
Do. .	(362) Do. . .	Do. . .	P. L. .	133	10th November 1923.	1 year.
Do. .	(363) Do. . .	Do. . .	P. L. .	158	Do. .	Do.
Do. .	(364) Messrs. B. P. Byramji & Co.	Do. . .	M. L. .	5	1st November 1923.	5 years
Do. .	(365) Messrs. B. N. Soparker & Co.	Do. . .	M. L. .	14	11th October 1923.	30 years.
Do. .	(366) Messrs. Tata Sons, Ltd.	Do. . .	M. L. .	600	1st November 1923.	Do.
Do. .	(367) Pandit Kripashanker.	Do. . .	P. L. .	23	31st October 1923.	1 year.
Do. .	(368) Mr. Sunderlal Golcha.	Do. . .	P. L. .	90	30th November 1923.	Do.
Do. .	(369) Do. . .	Do. . .	P. L. .	85	16th November 1923.	Do.
Do. .	(370) Seth Chagmal Kachar.	Do. . .	P. L. .	85	5th October 1923.	Do.
Do. .	(371) Do. . .	Do. . .	P. L. .	88	10th November 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(372) R. S. Narsingdass.	Mica . . .	P. L. .	42	5th October 1923.	1 year.
Do. .	(373) Do. . .	Manganese . .	P. L. .	15	Do.	Do.
Do. .	(374) Mr. C. Stanley Harris.	Do. . .	P. L. .	100	16th November 1923.	Do.
Do. .	(375) M. B. Chopra .	Do. . .	P. L. .	55	30th November 1923.	Do.
Betul .	(376) Mr. W. M. Moylon	Coal . . .	P. L. .	240	3rd January 1923.	Do.
Do. .	(377) Messrs. Bisheswarlal and Jagannath.	Do. . . .	P. L. .	475	12th March 1923.	Do.
Do. .	(378) Mr. Damji Deosi .	Do. . . .	P. L. .	33	8th January 1923.	Do.
Do. .	(379) Seth Girdharilal, Banker.	Do. . .	P. L. .	516	5th February 1923.	Do.
Do. .	(380) Patel Keshoram .	Do. . . .	P. L. .	168	24th March 1923.	Do.
Do. .	(381) Hazi Zahiruddin .	Do. . . .	P. L. .	282	3rd January 1923.	Do.
Do. .	(382) Patel Keshoram .	Do. . . .	P. L. .	178	24th March 1923.	Do.
Do. .	(383) Seth Minamal and Nandlal.	Do. . . .	P. L. .	406	27th February 1923.	Do.
Do. .	(384) Seth Hazarilal .	Do. . . .	P. L. .	33	1st March 1923.	Do.
Do. .	(385) Mr. Dinanath Patel	Iron and ferric-oxide.	P. L. .	92	9th January 1923.	Do.
Do. .	(386) Mr. Pratul Narayan Mukerji.	Coal . . .	P. L. .	1,481	30th January 1923.	Do.
Do. .	(387) Do. . .	Do. . . .	P. L. .	399	24th March 1923.	Do.
Do. .	(388) Mr. Nazir Ali Mohammad Ali.	Do. . . .	P. L. .	544	20th March 1923.	Do.
Do. .	(389) Thakur Prasad Awasthi.	Do. . . .	P. L. .	52	21st May 1923	Do.
Do. .	(390) Nazarali Mohommadali.	Do. . . .	P. L. .	444	26th May 1923	Do.
Do. .	(391) Do. . .	Do. . . .	P. L. .	365	Do. .	Do.
Bhandara .	(392) Mr. Shamji Narayanji.	Manganese . .	P. L. .	3	2nd February 1923.	Do.
Do. .	(393) Do. . .	Do. . .	P. L. .	10	Do. .	Do.
Do. .	(394) Do. . .	Do. . .	P. L. .	1	Do. .	Do.
Do.	(395) Mr. Bansidhar Ramniwas.	Do. . .	P. L. .	151	25th April 1923.	Do.

P. L. = *Prospecting License*. M. L. = *Mining Lease*.

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(396) Mr. Gulam Mohomed.	Manganese . .	P. L. .	172	2nd June 1923.	1 year.
Do. .	(397) Rai Sahib Gowardhan Das.	Do. .	P. L. .	35	30th June 1923.	Do.
Do. .	(398) Messrs. B. P. Byramji & Co.	Do. . .	M. L. .	3	8th May 1923	5 years.
Do. .	(399) Mr. Sunderlal Golcha.	Do. . .	P. L. .	101	26th July 1923	1 year.
Do. .	(400) Seth Karnidan Chogmal.	Do. . .	P. L. .	274	18th July 1923.	Do.
Do. .	(401) Do. . .	Do. . .	P. L. .	65	19th August 1923.	Do.
Do. .	(402) Rai Sahib Narayandas Khushalram.	Do. . .	P. L. .	19	11th August 1923.	Do.
Do. .	(403) Mr. Shamjee Narayanjee.	Do. . .	P. L. .	29	7th July 1923	Do.
Do. .	(404) Do. .	Do. . .	P. L. .	1	Do.	Do.
Do. .	(405) Messrs Lalbehari Narayandas and Ramcharan Shankerlal.	Do. . .	M. L. .	36	25th August 1923.	10 years.
Do. .	(406) Seth Karnidan Chhogmal.	Do. . .	P. L. .	689	21st October 1923.	1 year.
Do. .	(407) Manwarali Turabali Syndicate.	Do. . .	P. L.	278	8th October 1923.	Do.
Do. .	(408) Mr. Shriram Seth .	Do. . .	P. L. .	15	20th December 1923.	Do.
Do. .	(409) Mr. Lala Jainarayan.	Do. . .	P. L. .	19	12th November 1923.	Do.
Bilaspur .	(410) Messrs. Chari & Co. Calcutta.	Coal . . .	P. L. .	1,630	18th January 1923.	1 year.
Do. .	(411) Capt. W. J. Considine and Messrs. Dunlop Bros. & Co.	Do. . .	P. L. .	11,402	9th March 1923.	Do.
Do. .	(412) Do. .	Do. . .	P. L. .	3,376	10th November 1923.	Do.
Chanda .	(413) Rao Sahib D. Laxmi Narayan.	Do. . .	M. L. .	278	16th June 1923.	30 years.
Do. .	(414) Do. . .	Do. . .	P. L. .	597	3rd April 1923	1 year.
Do. .	(415) Do. . .	Do. . . .	P. L. .	1,874	Do. .	Do.
Do. .	(416) Hon'ble Sir M. B. Dadabhoy.	Do. . . .	P. L. .	559	11th May 1923	Do.
Do. .	(417) Rao Sahib D. Laxmi Narayan.	Do. . . .	P. L. .	73	28th August 1923..	Do.
Do. .	(418) Do. . .	Do. . . .	P. L. .	971	1st October 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chanda	(419) Rao Sahib D. Laxmi Narayan.	Coal	P. L.	948	26th November 1923.	1 year.
Chhindwara	(420) Mr. B.V. Buti	Do.	P. L.	299	6th January 1923.	Do.
Do.	(421) Diwan Bahadur Seth Ballabhdas.	Do.	P. L.	368	5th March 1923.	Do.
Do.	(422) Seth Hazarilal	Do.	P. L.	67	1st March 1923.	Do.
Do.	(423) Do.	Do.	P. L.	160	3rd January 1923.	Do.
Do.	(424) Do.	Do.	P. L.	193	Do.	Do.
Do.	(425) Sir Bissessardas Daga.	Manganese	P. L.	7	Do.	Do.
Do.	(426) Messrs B. Faujdar Bros.	Do.	P. L.	56	22nd January 1923.	Do.
Do.	(427) Mr. Bakaram Singh	Do.	P. L.	8	2nd March 1923.	Do.
Do.	(428) Do.	Do.	P. L.	152	Do.	Do.
Do.	(429) Hazi Zahiruddin	Coal	P. L.	51	21st March 1923.	Do.
Do.	(430) Messrs. B. Faujdar Bros.	Manganese	P. L.	37	19th February 1923.	Do.
Do.	(431) Rai Sahib Mathura Prasad Motilal & Co.	Coal	M. L.	540	3rd January 1923.	30 years.
Do.	(432) Rai Sahib Sunder Lal.	Do.	M. L.	616	30th January 1923.	Do.
Do.	(433) Seth Laxmichand of Betul.	Do.	M. L.	33	24th February 1923.	Do.
Do.	(434) Rai Sahib Seth Govardhandas.	Do.	M. L.	146	30th November 1922.	Do.
Do.	(435) Indian Manganese Co.	Manganese	M. L.	26	14th February 1923.	Till 31st May 1932.
Do.	(436) Rai Sahib A. P. Bhargava.	Coal	P. L.	160	5th April 1923.	1 year.
Do.	(437) Seth Hazarilal	Do.	P. L.	167	7th June 1923	Do.
Do.	(438) Mr. Noormohommad.	Do.	P. L.	133	16th April 1923.	Do.
Do.	(439) Hon'ble Sir M. B. Dadabhai.	Manganese	P. L.	41	9th May 1923	Do.
Do.	(440) Messrs. B. Fauzdar Bros.	Do.	P. L.	30	14th June 1923.	Do.
Do.	(441) Do.	Do.	P. L.	35	15th June 1923.	Do.
Do.	(442) Do.	Do.	P. L.	48	Do.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara	(443) Messrs. M. D. Costa & Gouridutt Ganeshlal.	Manganese	P. L.	140	28th June 1923.	1 year.
Do.	(444) Do.	Do.	P. L.	17	9th May 1923	Do.
Do.	(445) Seth Hazarilal	Do.	P. L.	10	25th June 1923.	Do.
Do.	(446) Pandit Kirpa Shanker.	Coal	M. L.	120	29th May 1923	30 years.
Do.	(447) Seth Laxmichand	Do.	M. L.	68	4th June 1923	Do.
Do.	(448) Rai Sahib Seth Gowardhandas.	Do.	M. L.	227	16th April 1923.	Do.
Do.	(449) Pandit Kirpa Shanker.	Do.	M. L.	383	29th May 1923	Do.
Do.	(450) Mr. Banshidhar Ramniwas.	Do.	M. L.	590	8th May 1923	Do.
Do.	(451) Haji Zahiruddin	Do.	M. L.	187	29th May 1923.	Do.
Do.	(452) Pandit Kedarnath Bhargava.	Do.	P. L.	126	7th July 1923	1 year.
Do.	(453) Messrs. Dannulal and others.	Do.	P. L.	148	5th July 1923	Do.
Do.	(454) Messrs. Abdul Kadir, Abdul Ali and Brothers.	Do.	P. L.	329	8th August 1923.	Do.
Do	(455) Rai Sahib Seth Govardhandas.	Do.	P. L.	67	16th July 1923.	Do.
Do.	(456) Khan Sahib M. Hasanji & Sons.	Manganese	P. L.	102	17th July 1923.	Do.
Do.	(457) Messrs. Dhannoolal and others.	Coal	P. L.	249	5th July 1923	Do.
Do.	(458) Rai Sahib Minamal Nandlal.	Do.	P. L.	820	8th August 1923.	Do.
Do.	(459) Messrs. Abdul Kadir Abdul Ali.	Do.	P. L.	149	3rd July 1923	Do.
Do.	(460) Messrs. M. D. Costa and Gouridutt Ganeshlal.	Do.	P. L.	176	20th July 1923	Do.
Do.	(461) Rajnath Dwarkanath.	Do.	P. L.	92	18th September 1923.	Do.
Do.	(462) Chhedilal Chaudhri	Do.	P. L.	340	15th August 1923.	Do.
Do.	(463) Messrs. B. Faujdar and Brothers.	Manganese	P. L.	21	27th September 1923.	Do.
Do.	(464) Seth Hazarilal Bazaz.	Do.	P. L.	41	12th July 1923.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara	(465) Seth Hazarilal Bazaz.	Manganese . .	P. L. .	100	3rd July 1923	1 year.
Do. .	(466) Mr. A. V. Wazalwar.	Do. . .	P. L. .	60	5th September 1923.	Do.
Do. .	(467) Messrs. M. D. Costa and Gouri Dutt Ganesh Lal.	Do. . .	P. L. .	7	12th September 1923.	Do.
Do. .	(468) Do. . .	Do. . .	P. L. .	49	Do. .	Do.
Do. .	(469) Do. . .	Do. . .	P. L. .	52	Do. .	Do.
Do. .	(470) Messrs. Shaw Wallace & Co.	Coal . . .	M. L. .	3	13th July 1923.	30 years.
Do. .	(471) Rai Sahib A. P. Bhargao.	Do. . . .	M. L. .	19	11th August 1923.	Do.
Do. .	(472) Rai Sahib Mathuraprosad, Moti Lal & Co.	Do. . . .	M. L. .	9	30th August 1923.	Do.
Do. .	(473) Seth Hazarimal Bazaz.	Do. . . .	P. L. .	65	4th October 1923.	1 year.
Do. .	(474) Do. . .	Manganese .	P. L. .	11	30th November 1923.	Do.
Do. .	(475) Do. . .	Do. . .	P. L. .	65	4th October 1923.	Do.
Do. .	(476) Messrs. Abdul Kader Abdullah and Bros.	Do. . .	P. L. .	31	22nd December 1923.	Do.
Do. .	(477) Patel Keshoram .	Coal . . .	P. L. .	118	28th November 1923.	Do.
Do. .	(478) Do. .	Do. . .	P. L. .	174	Do. .	Do.
Do. .	(479) Seth Hazarimal Bazaz.	Manganese . .	P. L. .	43	15th December 1923.	Do.
Do. .	(480) Mr. R. Bazaj .	Coal . . .	M. L. .	307	17th September 1923.	30 years.
Do. .	(481) Sheikh Shahabuddin & Sons.	Do. . . .	M. L. .	75	26th October 1923.	15 years.
Do. .	(482) Indian Manganese Co.	Manganese . .	M. L. .	13	1st November 1923.	Will expire with the mining lease dated 18th November 1914 to which it is supplementary.
Hoshangabad	(483) Seth Hazarilal .	Coal . . .	P. L. .	365	5th July 1923	1 year.
Do. .	(484) Pandit Mrityunjai Prasad Subedar.	Do. . . .	P. L. .	159	9th June 1923	Do.

P. L. = *Porspecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hoshangabad	(485) Rai Saheb Seth Jugalkishore.	Coal	P. L.	232	9th July 1923	1 year.
Do.	(486) Do.	Do.	P. L.	241	28th July 1923.	Do.
Do.	(487) Rai Sahib A. P. Bhargava.	Do.	P. L.	395	13th December 1923.	Do.
Do.	(488) Debiprosad Benia	Do.	P. L.	165	10th December 1923.	Do.
Jubbulpore.	(489) Tata Electro Chemicals, Ltd.	Bauxite	P. L.	169	24th March 1923.	1 year.
Do.	(490) Do.	Do.	P. L.	296	25th January 1923.	Do.
Do.	(491) Do.	Do.	P. L.	297	Do.	Do.
Do.	(492) Mr. G. H. Cook	Coal	P. L.	575	7th March 1923.	Do.
Do.	(493) Mr. George Forrester.	Bauxite	P. L.	215	25th January 1923.	Do.
Do.	(494) Rai Sahib Jugalkishore.	Coal	P. L.	496	9th January 1923.	Do.
Do.	(495) Mr. Thakur Prasad Awasthi.	Do.	P. L.	226	12th January 1923.	Do.
Do.	(496) Do.	Do.	P. L.	210	Do.	Do.
Do.	(497) Mr. Venkat Ramanna.	Do.	M. L.	36	27th February 1923.	30 years.
Do.	(498) Olpherts Paints & Products, Ltd.	Manganese, copper, gold and silver.	P. L.	1,006	7th March 1923.	1 year.
Do.	(499) Tata Electro Chemicals, Ld.	Bauxite	P. L.	693	16th April 1923.	Do.
Do.	(500) Do.	Do.	P. L.	397	Do.	Do.
Do.	(501) Mr. Venkat Ramanna.	Do.	M. L.	5	6th May 1923	30 years.
Do.	(502) The Electro Chemicals Ld.	Do.	P. L.	108	7th September 1923.	1 year.
Do.	(503) Do.	Do.	P. L.	58	15th September 1923.	Do.
Do.	(504) Do.	Do.	P. L.	24	Do.	Do.
Do.	(505) Mr. Kashi Prosad Pande.	Do.	M. L.	1	20th April 1923.	30 years.
Do.	(506) Mr. Venkat Ramanna.	Do.	M. L.	21	28th July 1923.	Do.
Do.	(507) Tata Electro Chemicals, Ld.	Do.	P. L.	477	12th October 1923.	1 year.
Do.	(508) Do.	Do.	P. L.	147	Do.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore.	(509) Tata Electro Chemicals, Ld.	Bauxite .	P. L. .	423	20th November 1923.	1 year.
Nagpur .	(510) Rai Sahib Seth Naraindas.	Manganese . .	P. L. .	72	2nd January 1923.	Do.
Do. .	(511) Do. . .	Do. . .	P. L. .	96	Do. .	Do.
Do. .	(512) The Central India Mining Co., Ld.	Do. . .	P. L. .	26	1st February 1923.	Do.
Do. .	(513) Rai Sahib Ramkrishna Puri Gosai.	Do. . .	P. L. .	663	16th March 1923.	Do.
Do. .	(514) Lala Jainarayan Mohonlal.	Do. . .	P. L. .	30	6th January 1923.	Do.
Do. .	(515) Messrs. N. D. Zal and Brothers.	Do. . .	P. L. .	104	2nd January 1923.	Do.
Do. .	(516) Mr. Shamji Narayanjee.	Do. . .	P. L. .	51	11th May 1923	Do.
Do. .	(517) Do. . .	Do. . .	P. L. .	97	Do. .	Do.
Do. .	(518) Do. . .	Do. . .	M. L. .	12	8th May 1923	5 years
Do. .	(519) Seth Karnidass Chogmal.	Do. . .	P. L. .	148	30th April 1923.	1 year.
Do. .	(520) Seth Meghraj Golcha.	Do. . .	P. L. .	106	26th April 1923.	Do.
Do. .	(521) Lala Jainarayan Mohanlal.	Do. . .	P. L. .	44	11th June 1923.	Do.
Do. .	(522) Messrs. Manwaali Turabli and Motilal.	Do. . .	P. L. .	27	12th May 1923	Do.
Do. .	(523) Do. . .	Do. . .	P. L. .	91	27th June 1923.	Do.
Do. .	(524) Mr. Ganpat Rao Laxman.	Do. . .	P. L. .	122	7th September 1923.	Do.
Do. .	(575) Mr. Karsanji Vellanji.	Do. . .	P. L. .	16	3rd August 1923.	Do.
Do. .	(526) Messrs. K. R. Pade and Dube.	Do. . .	P. L. .	115	11th September 1923.	Do.
Do. .	(527) Do. . .	Do. . .	P. L. .	127	12th September 1923.	Do.
Do. .	(528) Do. . .	Do. . .	P. L. .	167	11th September 1923.	Do.
Do. .	(529) Mr. Shriram Seth	Coal . . .	P. L. .	334	15th August 1923.	Do.
Do. .	(530) Messrs. Ramprasad and Laxminarayan.	Manganese . .	P. L. .	166	30th August 1923.	Do.
Do. .	(531) Do. . .	Do. . .	P. L. .	177	28th July 1923.	Do.
Do. .	(532) Rai Sahib Ramkrishna Puri.	Do. . .	P. L. .	124	3rd August 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(533) Rai Sahib Ramkrshnu Puri.	Manganese . .	P. L. .	7	3rd August 1923.	1 year.
Do. .	(534) Do. . .	Do. . .	P. L. .	35	7th September 1923.	Do.
Do. .	(535) Do. . .	Do. . .	P. L. .	45	Do. .	Do.
Do. .	(536) Messrs. Manwarali Turabali and Motilal.	Do. . .	P. L. .	28	15th August 1923.	Do.
Do. .	(537) Do. . .	Do. . .	P. L. .	37	21st September 1923.	Do.
Do. .	(538) Do. . .	Do. . .	P. L. .	39	7th September 1923.	Do.
Do. .	(539) Seth Bansidhar Ramniwas.	Do. . .	P. L. .	66	17th September 1923.	Do.
Do. .	(540) Messrs. Rajnath and Dwarkanath.	Do. . .	P. L. .	72	8th August 1923.	Do.
Do. .	(541) Mr. A. E. Tinch . .	Do. . .	P. L. .	134	17th September 1923.	Do.
Do. .	(542) Do. . .	Do. . .	P. L. .	140	Do. .	Do.
Do. .	(543) Do. . .	Do. . .	P. L. .	279	Do. .	Do.
Do. .	(544) Mr. S. Aminuddin	Do. . .	P. L. .	130	21st September 1923.	Do.
Do. .	(545) Rai Sahaib D. Laxmi Narayan.	Felspar . .	P. L. .	58	30th August 1923.	Do.
Do. .	(546) Rai Sahib Ramkrishna Puri.	Manganese . .	P. L. .	77	24th October 1923.	Do.
Do. .	(547) Do. . .	Do. . .	P. L. .	116	Do. .	Do.
Do. .	(548) Do. . .	Do. . .	P. L. .	15	3rd December 1923.	Do.
Do. .	(549) Do. . .	Do. . .	P. L. .	32	Do. .	Do.
Do. .	(550) Do. . .	Do. . .	P. L. .	35	24th October 1923.	Do.
Do. .	(551) Pandit Rewashankar.	Do. . .	P. L. .	159	20th November 1923.	Do.
Do. .	(552) Messrs. Abdul Kadir, Abdul Ali and Bros.	Do. . .	P. L. .	259	17th November 1923.	Do.
Do. .	(553) The Indian Manganese Co.	Do. . .	P. L. .	99	10th December 1923.	Do.
Do. .	(554) Seth Karnidan Chhogmal.	Do. . .	P. L. .	105	24th October 1923.	Do.
Do. .	(554) Do. . .	Do. . .	P. L. .	2	14th December 1923.	Do.
Do. .	(556) Hon'ble Sir M. B. Dadabhoy.	Do. . .	P. L. .	75	26th October 1923.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*concld.*

Distict.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(557) Seth Bansidhar Ramniwas.	Manganese . .	P. L. .	29	19th November 1923.	1 year.
Do. .	(558) Seth Meghraj Golcha.	Do. . .	P. L. .	56	22nd October 1923.	Do.
Do. .	(559) Do. . .	Do. . .	P. L. .	127	Do. .	Do.
Do. .	(560) Do. . .	Do. . .	P. L. .	40	26th October 1923.	Do.
Do. .	(561) Messrs. Rajnath and Dwarkanath.	Do. . .	P. L. .	8	Do. .	Do.
Do. .	(562) Do. . .	Do. . .	P. L. .	119	10th December 1923.	Do.
Do. .	(563) Seth Laxminarayan Hardeo.	Do. . .	P. L. .	44	3rd December 1923.	Do.
Do. .	(564) Do. . .	Do. . .	P. L. .	130	27th November 1923.	Do.
Do. .	(565) Syed Hifizul Raquib.	Do. . .	P. L. .	90	26th October 1923.	Do.
Do. .	(565) Mr. M. A. Razaq .	Do. . .	P. L. .	867	19th November 1923.	Do.
Do. .	(567) Messrs. Ramkrishna Ramnath & Co.	Do. . .	P. L. .	181	10th December 1923.	Do.
Narsinghpur	(568) Mr. C. Stanley Harris.	Copper . .	M. L. .	222	26th June 1923.	Do.
Saugor .	(569) Lala Pragnarayan.	Iron, iron pyrites, Sulphate of iron, Sulphur and Copper.	P. L. .	1,554	11th September 1923.	Do.
Yeotmal .	(570) Messrs. P. R. Patel & Co., Bombay.	Coal . . .	P. L. .	417	16th February 1923.	Do.
Do. .	(571) Do. . .	Do. .	P. L. .	580	Do. .	Do.

MADRAS.

Agency Division.	(572) Messrs. Best & Co.	Coal . . .	P. L. .	40,320	20th April 1923.	1 year.
Do.	(573) Do. .	Do. . .	P. L. .	5,280	11th April 1923.	Do.
Anantapur .	(574) A. Ghose, Esq .	Barytes . .	M. L. .	183·92	2nd October 1922.	30 years
Do. .	(575) Janab Nabi Sahib Bahadur.	Mica . . .	P. L. .	112·05	6th April 1923.	1 year.
Do. .	(576) Mr. B. P. Sesha Reddi Garu.	Barytes . .	P. L.	2·26	Do. .	Do.
Do. .	(577) Do. .	Steatite . .	P. L. .	27·96	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

MADRAS—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Anantapur .	(578) Superintendent, North Anantapur Gold Mines, Ltd.	Gold . . .	P. L. .	1,769·52	21st July 1923	1 year.
Do. .	(579) M. R. Ry. B. P. Sesha Reddi of Bethamcherla.	Steatite . .	M. L. .	27·96	1st November 1923.	30 years.
Bellary .	(580) A. Pichayya Nayudu.	Manganese . .	P. L. (renewal) .	601	15th October 1922.	1 year.
Do. .	(581) A. Pichayya Nayudu and K. C. Narasimbachari.	Do. . .	P. L. (renewal.) .	450	9th August 1922.	Do.
Do. .	(582) K. Ramchandra, Esq. Bar.-at Law.	Clay . . .	M. L. .	52·78	29th June 1923.	5 years.
Do. .	(583) Do. . .	Kaolin and other chemical earths.	P. L. .	200·1	Do.	1 year.
Do. .	(584) M. R. Ry. Pitchiya Nayudu.	Manganese . .	M. L. .	1,557·20	22nd August 1923.	30 years.
Do. .	(585) M. R. Ry. Patel Patta Basappa.	Do. . .	P. L. .	35·85	20th November 1923.	1 year.
Do. .	(586) M. R. Ry. Pitchiya Nayudu Garu . .	Do. . .	M. L. .	601	18th December 1923.	30 years.
Do. .	(587) Mr. K. Abdul Hye	Do. . .	P. L. .	46·30	20th November 1923.	1 year.
Cuddapah .	(588) A. Ghose, Esq. .	Barytes . .	P. L. .	127·58	6th June 1923.	Do.
Do. .	(589) M. R. Ry. B. Chinnamala Reddi Garu.	Barytes and Asbestos.	P. L. .	57·26	10th December 1923.	Do.
Karnool .	(590) M. R. Ry. R. A. Seshi Reddi Garu.	Barytes . .	P. L. .	2·07	29th June 1923.	Do.
Do. .	(591) Do. . .	Do. . .	P. L. .	9·5	Do.	Do.
Do. .	(592) Do. . .	Do. . .	P. L. .	13.79	Do.	Do.
Do. .	(593) Do. . .	Do. . .	M. L. .	3.21	Do.	30 years.
Do. .	(594) M. R. Ry. B. P. Sesha Reddi of Bethamcherla.	Manganese . .	P. L. .	46	7th August 1923.	1 year.
Do. .	(595) Do. . .	Steatite . .	M. L. .	69.4	Do.	30 years.
Malabar .	(596) Mr. W. H. Perry .	Gold . . .	P. L. .	80	20th June 1923	1 year.
Nellore .	(597) K. C. Narasimachari.	Mica . . .	P. L. .	112.51	11th January 1923.	Do.
Do. .	(598) Mr. T. C. Dandayutham Pillai.	Do. . .	P. L. .	8.82	2nd December 1922.	Do.
Do. .	(599) Mr. R. Ry Kali Chetty Venku Reddi of Marupur.	Do. . .	P. L. .	13.38	5th October 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

MADRAS—*concld.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(600) M. R. Ry. S. V. Subba Reddi Garu.	Mica . . .	M. L. .	152.30	5th October 1923.	30 years.
Nilgiris .	(601) Mr. A. H. Gaston	Do. . .	P. L. .	56.57	14th June 1922.	1 year.
Do. .	(602) Do. . .	Do. . .	P. L. .	62.84	12th February 1923.	Do.
Do. .	(603) Do. .	Do. . .	P. L. .	56.57	14th June 1923.	Do.
Do. . .	(604) Do. . .	Do. . .	P. L. .	303.90	18th December 1923.	Do.
Salem .	(605) R. Alagappa Mudaliyar.	Corundum . .	P. L. .	148.08	17th February 1923.	Do.
Do. .	(606) C. Middleton .	Magnesite . .	P. L. .	50.79	Do.	Do.
Do. .	(607) Captain E. K. Dickens.	Emery . .	P L. .	140	6th December 1923.	Do.

NORTH-WEST FRONTIER PROVINCE.

Kohat .	(608) Edwin John Beer, Esq.	All other minerals except oil *i. e.*, precious stone, gold and ores, particularly Stanlium and Sulphur.	P. L. . .	640	29th June 1923.	1 year.
Dera Ismail Khan.	(609) Messrs. Graham & Co., Calcutta, through Mr. G. E. Stall.	All minerals including mineral oil.	E. L. .	The area is covered by circle of 20 miles radius, the centre being Moghul Kot, Sherani country.	8th December 1923.	Do.

PUNJAB.

Jhelum .	(610) Jamada Fateh Ali Khan.	Coal . .	P. L.	13	10th January 1923	1 year.
Do.	(611) Do. . .	Do. . .	P. L. .	15	Do.	Do.
Do. .	(612) L. Chuni Lal Kapur.	Do. . .	P. L. .	82	15th January 1923.	Do.
Do.	(613) R. S. Thakur Das Ramjidas.	Do. . .	P. L. .	73.28	15th March 1923.	Do.
Do. .	(614) Do. . .	Do. . .	P. L. .	36.92	Do.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*
E. L.=Exploring License.

PUNJAB—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum .	(615) L. Ishar Das Kapur.	Coal . .	P. L. .	19	15th March 1923.	1 year.
Do. .	(616) Messrs. Whitehall Petroleum Corporation Ltd.	Oil . . .	P. L. .	934.40	30th April 1923.	Do.
Do. .	(617) Do. . .	Do. . .	P. L. .	2,784	Do.	Do.
Do. .	(618) L. Churanjit Lal of Wahali.	Coal . .	P. L. .	442.148	4th May 1923.	Do.
Do. .	(619) Pandit Gian Chand	Do. . .	P. L. .	117.25	5th June 1923.	Do.
Do. .	(620) Do. . .	Do. . .	M. L. .	364	Do.	30 years.
Do. .	(621) L. Chuni Lal Kapur.	Do. . .	P. L. .	311	Do.	1 year.
Do. .	(622) Do. . .	Do. . .	P. L. .	180.44	1st September 1923.	Do.
Do. .	(623) Punjab Coal Syndicate.	Do. . .	P. L. .	1,444.5	22nd October 1923.	Do.
Do. .	(624) R. G. Tugwood .	Oil . . .	P. L. .	3,200	12th November 1923.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

SUMMARY.

PROVINCE.	Exploring License.	Prospecting License.	Mining Lease.	Total of each Province.
Assam	..	12	1	13
Bengal	..	7	..	7
Bihar and Orissa	..	2	20	22
Bombay	..	2	1	3
Burma	..	243	39	282
Central Provinces	..	204	40	244
Madras	..	28	8	36
North-West Frontier Province . . .	1	1	..	2
Punjab	..	14	1	15
Total of each kind and grand total for 1923 .	1	513	110	624
TOTAL FOR 1922 .	..	562	110	672

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 39.—*Prospecting Licenses and Mining Leases granted in Assam during the year 1923.*

District.	1923.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Cachar	2	2,945·60	Mineral oil.
Garo Hills	7	13,440	Coal.
Lakhimpur	3	12,608	Mineral oil.
TOTAL	12	..	
Mining Lease.			
Lakhimpur	1	160	Oil.
TOTAL	1	..	

TABLE 40.—*Prospecting Licenses granted in Bengal during 1923.*

DISTRICT.	1923.		
	No.	Area in acres.	Mineral.
Prospecting License.			
Chittagong Hill Tracts	7	73,370·24	Mineral oil.

TABLE 41.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during 1923.*

District.	1923.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Sambalpur	1	114·28	Mica.
Do.	1	95·2	All minerals.
TOTAL	2	..	
Mining Leases.			
Hazaribagh	2	956	Mica.
Sambalpur	1	57·86	Do.
Santal Parganas	14	42·8	Coal.
Singhbhum	1	153·65	Manganese.
Do.	2	1,130	Chromite.
TOTAL	20	..	

TABLE 42.—*Prospecting Licenses and Mining Leases granted in Bombay during 1923.*

District.	1923.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Sukkur	2	32,755·38	Mineral oil.
Mining Lease.			
Belgaum	1	320	Manganese ore.

TABLE 43.—*Prospecting Licenses and Mining Leases granted in Burma during 1923.*

District.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Akyab	4	18,980	Mineral oil.
Amherst	3	16,000	Do.
Do.	5	3,070	All minerals (except oil).
Do.	2	35,622·40	Oil shale.
Do.	1	15,520	Mineral oil and oil shale.
Bhamo	1	3,328	All minerals (except mineral oil and jade).
Henzada	1	640	Mineral oil.
Do.	1	4,640	Coal.
Katha	4	2,202	All minerals (except oil).
Lower Chindwin	8	45,895·60	Mineral oil.
Magwe	33	50,186·30	Do.
Mandalay	1	2,560	All minerals (except oil).
Mergui	8	7,260·16	Tin and allied minerals.
Do.	12	12,822·26	Tin.
Do.	1	640	Cassiterite and gold.
Do.	1	1,120	Wolfram, tin and allied minerals.
Do.	7	12,835·84	All minerals (except oil).
Do.	2	6,277·12	Mineral oil and coal.
Do.	1	2,201·80	Coal.
Minbu	17	24,977·65	Mineral oil.
Do.	2	9,920	All minerals including mineral oil.
Do.	1	220	Coal and mineral oil.
Myingyan	7	22,138·40	Mineral oil.
Northern Shan States	4	1,570	Iron.
Do.	2	5,120	All minerals (except oil).
Pakokku	15	26,631·2	Mineral oil.
Prome	7	19,704·32	Do.
Do.	2	7,001·60	All minerals except amber and jadeite.
Shwebo	6	47,635·20	Mineral oil.
Do.	1	1,920	All minerals (except oil).
Do.	1	1,920	Coal.
Southern Shan States	8	25,012·97	All minerals (except oil).
Do.	1	40	Lead.
Do.	2	6,080	Gold, copper, etc.
Tavoy	10	4,302·60	Tin and wolfram.
Do.	6	3,548·10	All minerals except oil.
Do.	5	2,829	Tin and allied minerals
Do.	3	5,120	Tin and other minerals.
Do.	2	166·5	Tin.
Carried over	198	..	

TABLE 43.—*Prospecting Licenses and Mining Leases granted in Burma during 1923*—contd.

DISTRICT.	1923.		
	No.	Area in acres.	Mineral.
Prospecting Licenses—*contd.*			
Brought forward	198		
Tharrawaddy	1	640	Mineral oil.
Thaton	1	505·6	Tin.
Thayetmyo	31	127,279·12	Mineral oil.
Upper Chindwin	6	25,894·40	Do.
Do.	3	12,672	Mineral oil and coal.
Do.	3	14,105·6	Coal.
TOTAL	243	..	
Mining Leases.			
Amherst	3	1,881·60	Tin Ore.
Bhamo	1	3,232·62	All minerals (except oil and precious stones).
Henzada	1	236·8	Iron pyrite.
Katha	1	1,820	Graphite.
Magwe	1	640	Mineral oil.
Mergui	11	5,275·56	Tin.
Do.	2	5,416·36	All minerals (except oil).
Do.	2	931·84	Tin and allied minerals.
Do.	1	1,418·24	Tin and Wolfram.
Minbu	3	1,828	Mineral oil.
Northern Shan States	2	640	Iron.
Prome	1	409·60	Mineral oil.
Tavoy	4	1,762·90	Tin and Wolfram.
Do.	2	544·41	All minerals except oil.
Do.	1	817·53	Tin and allied minerals.
Do.	1	657	Wolfram, tin and allied minerals.
Thayetmyo	2	640	Mineral oil.
TOTAL	39	..	

TABLE 44.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1923.*

District.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Balaghat	32	2,823	Manganese.
Do.	2	82	Mica.
Betul	15	5,616	Coal.
Do.	1	92	Iron and ferric oxide.
Bhandara	16	1,862	Manganese.
Bilaspur	3	16,408	Coal.
Chanda	6	5,022	Do.
Chhindwara	31	2,444	Manganese.
Do.	15	2,688	Coal.
Hoshangabad	6	1,557	Do.
Jubbulpore	12	3,394	Bauxite.
Do.	4	1,507	Coal.
Do.	1	1,906	Manganese, copper, gold and silver.
Nagpur	55	6,246	Manganese.
Do.	1	334	Coal.
Do.	1	58	Felspar.
Saugor	1	1,554	Iron, iron pyrites, sulphate of iron, sulphur and copper.
Yeotmal	2	997	Coal.
TOTAL	204	..	
Mining Leases.			
Balaghat	14	918	Manganese.
Bhandara	2	39	Do.
Chanda	1	278	Coal.
Chhindwara	15	3,323	Do.
Do.	2	39	Manganese.
Jubbulpore	3	27	Bauxite.
Do.	1	36	Coal.
Nagpur	1	12	Manganese.
Narsinghpur	1	222	Copper.
TOTAL	40	..	

TABLE 45.—*Prospecting Licenses and Mining Leases granted in Madras during 1923.*

DISTRICT.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Agency Division	2	45,600	Coal.
Anantapur	1	112·05	Mica.
Do.	1	2·26	Barytes.
Do.	1	27·96	Steatite.
Do.	1	1,769·52	Gold.
Bellary	4	1,133·15	Manganese.
Do.	1	200·1	Kaolin and other chemical earths.
Cuddapah	1	127·58	Barytes.
Do.	1	57·26	Barytes and asbestos.
Kurnool	3	25·36	Barytes.
Do.	1	46	Manganese.
Malabar	1	80	Gold.
Nellore	3	134·71	Mica.
Nilgiris	4	479·88	Do.
Salem	1	148·08	Corundum
Do.	1	50·79	Magnesite.
Do.	1	140	Emery.
TOTAL	28	..	
Mining Leases.			
Anantapur	1	183·92	Barytes.
Do.	1	27·96	Steatite.
Bellary	1	52·78	Clay.
Do.	2	2,158·20	Manganese.
Kurnool	1	3·21	Barytes.
Do.	1	69·4	Steatite.
Nellore	1	152·30	Mica.
TOTAL	8	..	

TABLE 46.—*Prospecting and Exploring Licenses granted in North-West Frontier Province during 1923.*

DISTRICT.	1923.		
	No.	Area in acres.	Mineral.
Prospecting License.			
Kohat	1	640	All other minerals except oil, *i.e.*, precious stone gold and ores, particularly stanlium and sulphur.
Exploring License.			
Dera Ismail Khan . . .	1	The area is covered by circle of 20 miles radius, the centre being Moghal kot Sherani country.	All Minerals including mineral oil.

TABLE 47.—*Prospecting Licenses and Mining Leases granted in the Punjab during 1923.*

DISTRICT.	1923.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Jhelum	11	2,734	Coal.
Do.	3	6,918	Oil.
TOTAL .	14	..	
Mining Lease.			
Jhelum	1	364	Coal.

THE SODA-BEARING ROCKS OF KISHENGARH, RAJPUTANA, BY A. M. HERON, D.SC., F.G.S., *Officiating Superintendent, Geological Survey of India.* (With Plates 2 to 12.).

INTRODUCTION.

THE interesting elæolite and sodalite bearing rocks of Kishengarh were first known from specimens sent to the Geological Survey of India by Rao Bahadur Syam Sunder Lall, C.I.E., Diwan of Kishengarh State, and a short note on them was contributed by the late Mr. E. Vredenburg.[1] Mr. Vredenburg draws attention to the colour change of the elæolite-sodalite-pegmatite as follows :—

"Moreover some of the sodalite exhibits an extraordinary phenomenon hitherto unrecorded in any mineral. While some of the specimens are of a bright blue colour similar to that of the mineral from many other localities, others appear under ordinary conditions transparent and colourless. But some of these colourless fragments when kept in the dark for a fortnight or three weeks assume a pink colour which disappears rapidly on exposure to bright daylight, and almost instantaneously in direct sunshine.

The phenomenon is particularly brilliant when the rock is first broken in the field, and the large blocks of elæolite (some of which are over a yard wide) appear, on fracture, as if suffused with blood. The colour seems to re-appear more completely in some specimens than in others, for while the disappearance of the colour is very rapid, its re-appearance, which constitutes the most remarkable feature of the change, is very slow. The precise nature and cause of this peculiar phenomenon are at present unknown. The following analysis gives the percentage composition of a specimen of the blue sodalite :—

Loss on ignition	0·82
SiO_2 (Silica)	38·055
Al_2O_3 (Alumina)	31·30
Fe_2O_3 (Iron sesquioxide)	trace.
CaO (Lime)	0·001
Na_2O (Soda)	24·77
SO_3 (Sulphur trioxide)	trace.
Cl (Chlorine)	7·18
Less oxygen equivalent of chlorine	1·618
TOTAL	100·508
Specific gravity	2·27

[1] *Rec., Geol. Surv. Ind.,* XXXI, p. 43 (1904).

The other variety exhibiting the curious change of colour has been found so intimately intergrown with elæolite that it is not possible to obtain a complete analysis. Partial analysis indicates, however, almost exactly the same percentage as for the blue variety.

The elæolite-bearing rocks are surrounded by scapolite-gneisses and all the syenites contain scapolite associated with the elæolite and sodalite. The elæolite-sodalite-pegmatite contains large crystals of ægirine, sphene and lime-iron-garnet."

In the annual report for 1903-4, Sir Thomas Holland draws attention to the same peculiarity :[1]

"When freshly broken, the patches of sodalite are carmine in colour and the fresh rock-face gives the appearance of being splashed with blood, but in daylight the colour rapidly, and in direct sunlight almost suddenly, disappears. Many of the specimens when kept in the dark for a few months recover their carmine colour, losing it again on exposure either to daylight or to electric light. The sodalite does not, so far as we can find, differ in chemical composition from the ordinary varieties of the mineral, and neither the loss nor the recovery of colour is affected by the humidity of the atmosphere."

The discovery of cancrinite, by Babu Baidyanath Saha, is also recorded from the north-east extension of the main syenite mass. During the field study and collection of specimens of the syenites I was accompanied by Dr. Murray Stuart, whose co-operation I gratefully acknowledge.

General Geology.

Within an area 10 miles long by 2 miles wide, lying north-east from Kishengarh City (26° 34′ : 74° 55′), are one large and nine small masses of syenite in the form of sill-like intrusions in the Aravalli schists, markedly elongated in the general direction of the strike of these rocks, the syenites themselves being strongly banded and foliated in the same direction.

The rocks of the Aravalli System here consist chiefly of micaceous thin-bedded quartzites, quartz-mica-schists and mica-sillimanite-schists, all highly metamorphosed and intruded by amphibolite,[2] granite and pegmatite. A mile east of Kishengarh Railway Station the road crosses an anticline of impure vitreous quartzites, inter-

[1] *Rec., Geol. Surv. Ind.,* XXXII, p. 158 (1905).

[2] "Epidiorite" according to the recommendations of the Joint Committee on Petrographic Nomenclature.

bedded with which is a bed of graphitic mica-schist, about 4 feet thick, from which a mineral paint has been made and used on railway rolling stock. A mile or two still further to the south-east vein granites and pegmatites are so abundant in the Aravallis that the result is a banded rock or injection gneiss ("migmatite" of Sederholm[1]) in which ramifying and interfoliating veins penetrate the rock to such a degree that over large areas there is not a square foot free from them.

Besides these, numerous lenticular bosses of intrusive granite occur, some of large size, but those in the immediate vicinity of the syenites are insignificant. These granites are often foliated and in general resemble in their minerals the vein granites. The final result, especially where pressure has acted upon and rolled out the vein granite, is a banded rock which may be termed a "gneiss," interspersed with, and often merging imperceptibly into, areas of "gneissic granite" or "granitic gneiss". The complex is highly puzzling at first sight, but some of its obscurities are resolved by close study.

The evidence available goes to prove that the soda-syenites and their associated pegmatites were intruded previous to the deposition of the overlying Delhi System, the base of which lies a mile to the west of Kishengarh City. As the syenites are, so far as was seen, not penetrated by any of the very numerous granites, pegmatites and amphibolites (epidiorites) which are in such force in the surrounding rocks, it is at least possible that their absence may be due to the syenites being later in their period of intrusion than any of the others. Above, *i.e.*, to the west of the Delhi-Aravalli unconformity, no exposures of syenite are found, and, as the accompanying geological map shows, the line of the unconformity appears to cut across the strike of the syenite sills and the Aravalli schists at a low angle.

The basal beds of the Delhi system, to a thickness of more than 2,000 feet, are exposed in the high ridge which overlooks the plain of Aravalli rocks, and consists of felspathic conglomerates dipping away from the Aravallis at angles of 80° and higher. From Kishengarh City the unconformity has been followed to the south-west as far as my survey has proceeded, for nearly 80 miles; 6 miles to the north-east the ridge is interrupted by alluvium but is met

[1] "On Regional Granitisation (or Anatexis)," *Congrès Gèologique International*, 12th session (1 13).

with again along its strike-continuation, in the great mass of conglomeratic quartzites at Khakirdi, on the southern shore of the Sambhar Lake, and again to the north of the Lake in the conglomerates of Marot in Jodhpur. All along, wherever exposed, the unconformity is accompanied by arkose and conglomeratic beds, but their thickness is very variable from point to point, partly owing to original inequalities of accumulation, and partly due to repetition in some places and cutting-out in others, by multiple thrust-faults and slides along the unconformity.

In connection with the faulting may be noted the puzzling discovery of five or six large fragments of syenite along the base of a ridge parallel to, and at a distance of 4 miles to the west of, the range which marks the unconformity. Ruling out human transportation, which is quite unlikely, these fragments may have come either from a body of syenite close at hand but concealed below alluvium, or may have weathered, as boulders, from an irregular conglomerate which appears in the ridge and is derived from the disintegration of Aravalli rocks. In either case, taking into account the fact that the facies of the rocks of this ridge suggests that they are at or near the base of the Delhi System, it is possible that the lowest beds of the Delhis, with a section of the Aravallis, are here repeated by a strike-fault; unfortunately alluvium is so extensive and so deep that other field evidence cannot be obtained.

In the Kishengarh neighbourhood the Delhis above the basal beds are almost entirely concealed, but further to the south-west, towards Ajmer and Beawar, good sections are obtained, which show them to consist of thick quartzites, mica-schists and impure limestones folded synclinally into the Aravallis, with a great development of intrusive pegmatite, granite and amphibolite (epidiorite). The rock types are more definite in the Delhis than in the Aravallis, and in the former the various congeries of quartzites, mica-rocks and limestones, as the case may be, are thicker and more uniform within each set, whereas the Aravallis have a certain indefiniteness of character and such quartzites and calcareous bands as occur in them are thin and intercalated with the predominant rock-type—mica-schist.

The scenery reflects the geological structure. In the Delhis we have high continuous ridges of quartzites and, to a less extent, of limestone, alternating with valleys eroded along the softer rocks, while the Aravallis form a monotonous "gneissic plain."

The earlier pre-Delhi granite and pegmatite intrusive into the Aravallis, are distinct and distinguishable from the later post-Delhi granite and pegmatite.

Description of the Syenites.

The ten masses of syenite are on different horizons, and the largest has an irregular margin, owing to the low and variable dip of the rocks enclosing it, to which it is roughly parallel but to a certain extent transgressive. The four outcrops farthest to the north-east are isolated in, and separated from each other by, alluvium and the real form of the intrusions to which they belong is accordingly unknown.

In texture the syenite is very variable but may be divided into three mutually merging varieties :—a granitoid type in which the minerals are evenly distributed with no orientation in any particular direction, a foliated type in which the small patches of the different minerals are elongated in parallel planes, and a banded type in which layers of rock poor in dark ferro-magnesian minerals, an inch or two wide, alternate with basic bands of about the same thickness, consisting almost entirely of ferro-magnesians. In the first the clusters of amphibole are compact (glomero-porphyritic texture of Judd)[1], but in the two other varieties are markedly crushed and broken up, as if by motion in a semi-consolidated magma (glomero-plasmatic texture of Lœwinson-Lessing).[2]

Both foliation and banding follow the foliation of the enclosing Aravalli rocks, the largest mass is very strongly banded or foliated over most of its outcrop, and its foliation dips are at low angles, 20°—40° to north-west and west-north-west, and are notably regular, taken as a whole, though in detail often much corrugated.

In the field the grain of the rock is that of a somewhat coarse, non-porphyritic granite, but as explained below, the grain under the microscope, is much finer than is macroscopically apparent, for what appear to be mineral individuals are in reality aggregates of like minerals.

[1] *Quart. Journ. Geol. Soc.*, XLII, (1886), p. 71.

[2] "Geologische Skizze der Besitzung Jushno-Saosersk und des Berges Deneshkin Kamen in nördl. Ural," (1900), p. 208.

In hand specimens, or more clearly on weathered surfaces, it appears to have three mineral constituents :—(*a*) grey, with a greenish tinge and greasy lustre, which weathers more readily than the other two, thus giving rise to recesses and producing the conspicuous pitted surface characteristic of the syenite, (*b*) in about equal amount to (*a*), an aggregate of pure white granular crystals with pearly lustre, projecting in relief on weathering and sometimes showing simple twinning to the naked eye, (*c*) a greenish black mineral, in less amount than either (*a*) or (*b*), weathering more readily than (*b*) and less readily than (*a*), seen in hand specimens to be made up of interfelted elongated crystals showing a distinct cleavage. (*a*) The greyish constituent is under the microscope seen to be clusters of nepheline grains with a certain intermixture of felspars, (*b*) is essentially an aggregate of orthoclase and microcline (probably soda-microcline) with some albite, and (*c*) is mainly amphibole with sphene and apatite. Biotite and garnet are also present in some modifications.

There is thus visible in the field an almost complete differentiation of the magma into three portions, consisting essentially of felspathoids, felspars and ferro-magnesians. Doubtless had crystallization taken place under static conditions these patches would have produced large crystals, but owing to slight movement in the magma during consolidation, crystallization round certain centres has been interfered with, and a somewhat granulitic rock results of aggregates composed more or less of one mineral. Holland has drawn attention to the prevalence of this tendency (glomero-plasmatic texture of Lœwinson-Lessing) in the charnockites and the Sivamalai syenites.[1] Further movement under pressure produces the foliated varieties [2] wherein these aggregates of crystallization are drawn out into lenticles and sheets.

In the syenite, nepheline occurs in two generations, the older of rounded phenocrysts, of small size, and the younger of small allotriomorphic grains scattered through the felspathic groundmass.

As well as phenocrysts of nepheline, there are in the granitoid variety less numerous phenocrysts of microcline which do not show

[1] *Mem., Geol. Surv. Ind.*, XXVIII, pp. 152, 241, (1900) ; *Mem., Geol. Surv. Ind.*, XXX, p. 195, (1901).

[2] *Mem., Geol. Surv. Ind.*, XXVIII, p. 221, (1900) ; Bonney and McMahon, "Crystalline rocks of the Lizard district," *Quart. Journ. Geol. Soc.*, XLVII, p. 478, (1891).

crystal outlines. The finer groundmass consists largely of felspar, which under the microscope appears as an equidimensional mosaic of clear grains. These are clear and unweathered, and are mostly untwinned and probably orthoclase, but microcline, albite and oligoclase also occur in subordinate amount. The plagioclases were identified by the method of Michel-Lévy—of extinction angles measured from the trace of the albite lamellation. Perthitic intergrowths of microcline with orthoclase are frequent. Among the felspars cancrinite and calcite are present interstitially in small amounts and are certainly primary constituents. The Becke method of gelatinising with hydrofluoric acid and staining with malachite green was used in an attempt to identify quartz, which appears to be absent.

The texture of this groundmass is the same as the "mosaic texture" illustrated by Holmes[1] and Weinschenk and Johannsen.[2]

The ferro-magnesian minerals are abundant and occur in irregular clusters consisting of both biotite, with small included zircons, and the characteristic amphibole of the rock, with sphene and apatite in considerable amount and in some slides corroded garnets, brown (melanite) and pale pink (almandine). The amphibole is in large ragged plates and may be classified as a hornblende with an abnormally high extinction angle, 36° as a maximum, and pleochroic from deep blue-green to greyish-yellow.

The composition of the foliated variety does not differ materially from the above, except that the minerals have a distinct banded or lenticular arrangement and are, in some slides, but not always, seen to be crushed. The ferro-magnesian minerals make up a larger proportion of this than they do in the granitoid variety and are still more abundant, relatively, in the banded type.

In the latter the phenocrysts of nepheline are sometimes irregular and broken, and surrounded by fine detached particles. The felspathic groundmass may have "mortar" texture[3], or may be mylonised and granulitic in part.

[1] Holmes, "Petrographic Methods and Calculations," pl. 4, fig. 6.

[2] Weinschenk and Johannsen, "Fundamental Principles of Petrology," pl. 5, fig., pl. 6, fig. 1.

[3] Weinschenk and Johannsen, op. cit, pl. V, fig. 4.

Analyses of Indian Soda-syenites.

	Normal syenite, Kishengarh. (B. C. Gupta).	Dark banded syenite, Kishengarh. (B. C. Gupta.)	Vizagapatam syenite. (T. L. Walker).	Sivamalai syenite. (T. L. Walker).	Miaskite, Urals[1]. (M. Bourdakow).
SiO_2 .	55·32	54·52	52·60	55·68	56·26
Al_2O_3 .	23·78	24·32	26·60	23·81	23·59
Fe_2O_3 .	4·73	6·62	Fe_2O_3 ·91; FeO 2·21	4·84	Fe_2O_3 ·85; FeO 2·61
MgO .	1·07	·43	·51	·65	·27
CaO .	1·18	1·71	1·89	1·69	·54
Na_2O .	8·46	10·62	7·06	9·23	7·77
K_2O .	4·50	1·60	6·94	5·16	5·72
H_2O .	..	..	·61	·34	·37
Cl . .	·64	·99	..	..	
	99·68	100·81	CO_2 ·55	Graphite ·58	CO_2 1·37
Less O	·14	·22	..	..	TiO_2 ·47; MnO ·09
	99·54	100·59	99·88	101·98	99·91

Felspathoid-bearing rocks have hitherto been recorded from four other localities in India—Sivamalai, elæolite-syenite described by Sir Thomas Holland[2]; Vizagapatam, a miaskite described by T. L. Walker[3]; Mount Girnar, Kathiawar, a monchiquite described by J. W. Evans[4]; and from Sarnu, Jodhpur, a tinguaite described by Sir Thomas Holland[5].

All of these are too distant from Kishengarh for any magmatic relationship to be likely. The Kishengarh rock appears to correspond more or less with miaskite, grading towards shonkinite in the dark portions.

The Associated Pegmatites.

Traversing the various exposures are one or two veins of micro-syenite of small size and differing from the normal rock only in texture but not in composition, and also a few large veins of coarse pegmatite of great interest from the minerals they carry. The commonest

[1] Karpinsky, Guide, VII Cong. Geol. Inter., V, p. 22, (1897).
[2] *Mem., Geol. Surv. Ind.*, XXX, pp. 169—217, (1901).
[3] *Gen. Rep., Geol. Surv. Ind.*, 1902—3, p. 25; *Rec., Geol. Surv. Ind.*, XXXVI, pp. 19—22, (1907).
[4] *Q. J. G. S.*, LVII, pp. 38—54, (1901).
[5] *Mem., Geol. Surv. Ind.*, XXXV, p. 92, (1902).

are composed of the amphibole of the syenite but in large crystals and aggregates, with quartz, microcline and other felspars. These occur in force beyond the margin of the main syenite body, in the low scarp of quartzites to the south-east of it, and are in fact more numerous outside the syenite than within its limits. Another common variety carries large individuals of grey elæolite sometimes more than a foot in diameter with interstitial finely granular material consisting of sodalite and of an intergrowth of elæolite and sodalite, occasionally accompanied by cancrinite. The sodalite is intensely blue or colourless and is otherwise distinguishable from the elæolite by its greater transparency, saccharoidal granularity and by its brighter lustre as compared with the characteristic greasy aspect of the latter. The remarkable fading of the carmine tint of the freshly broken rock takes place in this type of pegmatite when the sodalite is colourless, but by no means all the colourless sodalite exhibits this property. The quartz-felspar-amphibole and elæolite-sodalite pegmatites occur most commonly and in the largest veins; the others are in small and scarce bodies. Perhaps the most striking is the bizarre rock consisting of pure white felspar veined and marbled with deep blue sodalite, bright yellow cancrinite and shining black biotite. The felspar is microcline perthitically intergrown with orthoclase and also the two species in granular aggregates. The sodalite and cancrinite are also granular, in veins containing both, or of sodalite alone, in the former case the sodalite being colourless, in the latter blue. Near Mandaoria in particular as well as at other points within the syenite masses, are veins of a pegmatite in which cancrinite is the principal mineral, in granular masses and large crystals up to a foot in length, with sodalite and biotite. The cancrinite appears to have crystallised before the sodalite, which is in veins and interspaces between the cancrinite crystals.

Another form of pegmatite is characterised by large idiomorphic pale pink garnets in cancrinite and felspar (albite and oligoclase in part) with biotite, apatite, sphene and sometimes calcite. The felspars are somewhat cloudy, show cleavage clearly, and have irregular and interlocking margins—"sutured" texture[1]—with much interstitial fine material. In the coarse granitoid rock adjoining this pegmatite the felspars show granophyric structure. This pegma-

[1] Weinschenk and Johannsen, op. cit., pl. V, figs. 2 and 3.

tite also carries molybdenite as a rare accessory, but I may parenthetically remark, it is not in economic quantity. Brown garnet (melanite), very similar to that of the syenite of Girnar, Kathiawar, is also found in pegmatite as well as in the normal rock, but in the pegmatite it occurs as small veins, unlike the pink garnet, which gives well formed crystals.

Pyroxene has only very doubtfully been recognized in the syenite, in small green grains, and if really present, is quite an unimportant constituent. There is however, one occurrence south of Mandaoria, where large crystals of ægirine-augite are enclosed in an elæolite-sodalite-microcline pegmatite and also, with amphibole, in the immediately adjoining syenite.

In the Boharu hill, the outcrop farthest to the north-east, which is composed of the normal unfoliated or granitoid form of syenite, the associated pegmatites consist of elæolite, sodalite and a white felspar, which on microscopical examination proves to be microcline, perthitically intergrown with oligoclase.

The Tilornia body is aberrant in that felspathoids are absent, quartz is present in small veins, and the principal ferro-magnesian appears, but doubtfully, to be a green pyroxene in ragged aggregates, with sphene and iron ores. The felspars are microcline and orthoclase. In the associated pegmatites however, amphibole is largely developed, both in large, stout crystals and fibrous bundles. This amphibole is the same as that of the syenite in the other intrusions.

Contact Rocks.

The rocks enclosing the syenites have been briefly alluded to. Limestones are by no means common in the Aravallis, but an interesting and handsome calcareous contact rock has been found at several places near Mandaoria, just outside the eastern margin of the main syenite mass, not in a definite bed, but in scattered and isolated blocks without visible arrangement. It is a white or pale grey saccharoidal rock, fine-grained, with scattered and ill-defined blotches of rose-pink and pinkish-yellow, in which a fibrous structure is apparent. The white portion of the rock is seen under the microscope to be made up of calcite and cancrinite in about equal amount, the latter in parallel blades and fibres or in irregular plates and elongated scales, which are in approximate optical continuity and extinguish together over the field of view, with the calcite scattered through it, and also in lenticles. In another variety a mosaic of secondary felspars with sutured margins encloses linearly-arranged scales of calcite and cancrinite, thus indicating the general fibrous nature of the rock. The pink portions of the rock consist of dendritic clusters and radiating wisps of elongated crystals of a pink, feebly pleochroic zoisite containing manganese, which with crossed nicols gives anomalous yellow and indigo interference colours, (see p. 196).

The scapolite gneisses recorded by Vredenburg have not been recognised, and two of his specimens thus designated prove on examination to be melanocratic varieties of the syenite; when he visited the locality cancrinite had not been recorded by Babu Baidyanath Saha and it is probable that cancrinite was mistaken for scapolite, as the two minerals are quite indistinguishable in micro-sections, unless basal sections, are available showing the intersections of the prismatic cleavages, in cancrinite meeting at 60°, in scapolite at 90°.

Notes on the constituent minerals.

Elæolite.

I use the name elæolite for the dominant felspathoid of these rocks, according to the customary usage of that term for the massive variety of nepheline found in plutonic rocks. In this case, so clear and unaltered is the mineral, that as far as the petrological characteristics of the mineral itself are concerned, it might with equal propriety be called nepheline.

Both in the syenite and the associated pegmatites it weathers with a thin soft yellowish-grey crust resembling the chalky crust on flint, but this decomposition is superficial, and immediately underneath the mineral is found to be quite fresh. When in small aggregates, as in the body of the syenite surrounded by felspars and ferro-magnesians of superior resistant powers, it weathers in recesses giving rise to the highly characteristic pitted aspect of the rock; but in the large masses in the pegmatites the chalk-like crust is readily removed by wind and rain and the peculiar greasy lustre and grey colour of the mineral are made apparent.

In the typical syenite the elæolite appears to be of two generations. The older consists of rather rounded individuals, sometimes showing an approximation to hexagonal outlines, perfectly clear, colourless and remarkably fresh, but with minute colourless or pale green platy inclusions, arranged linearly in parallel with the direction of extinction in longitudinal sections, and in transverse sections in lines intersecting at 60°, *i.e.*, parallel with the prism faces of the crystals. In some cases the inclusions themselves have straight extinctions; they appear to be minute laths of acid plagioclase and biotite, and the green ones may be amphibole or pyroxene, but they are not determinable with certainty. Only exceptionally does the elæolite show prismatic cleavage, in basal sections intersecting at 60°. The later generation is in smaller grains without inclusions, and is also clear and colourless. Usually it forms a fine-grained mosaic with the felspars, from which it is sometimes difficult to distinguish.

The mineral is usually distinguishable by its low double refraction and by the uniaxial figure given by suitable basal sections, but gelatinization with hydrochloric acid and staining with malachite green or fuchsine, performed either on microscope sections or on polished blocks, displays the proportion which the elæolite bears to the other components and also shows its tendency to segregate in patches, leaving the intervening areas occupied mainly by felspars, but with small amounts of it with them.

In the basic bands and lenticles, where ferro-magnesian minerals predominate, elæolite is not found. In the pegmatites elæolite occurs in intimate association with sodalite, the typical arrangement being of large individuals of elæolite often several inches in diameter, but without crystal outlines, separated by interstitial matter consisting of granular elæolite and sodalite in a form of intergrowth. Cancrinite and biotite are frequently found with this type.

An analysis of a portion of one of those large individuals gives :—

	Kishengarh[1]. (B. C. Gupta). Per cent.	Sivamalai[2]. (T. H. Holland). Per cent.
SiO_2	39·04	43·35
Al_2O_3	35·36	34·32
Fe_2O_3	trace	1·02
MgO	0·40	..
CaO	*Nil.*	0·82
Na_2O	17·998	14·62
K_2O	4·33	5·52
H_2O	..	..
Cl	3·91 Loss on ignition.	0·75
	101·038	
Less O.	0·880	..
TOTAL	100·158	100·40

Performed in the Laboratory of the Geological Survey of India.

I have attached for comparison the analysis of the Sivamalai elæolite given by Holland[2]. The percentage of chlorine, 3·91, shows that the Kishengarh mineral is considerably contaminated with sodalite.

Felspars.

Microcline, orthoclase, albite and oligoclase are present. Microcline, like the elæolite, occurs in two generations in the syenite, neither being in idiomorphic crystals. The earlier and larger individuals are about the same size as those of the earlier elæolite, and the smaller and later are in small grains, forming with the other felspars the bulk of the rock. Twinning according to the pericline mode is often on so fine a scale as to suggest that the felspar may be soda-microcline (anorthoclase). The practical impossibility of isolating a product unmixed with other felspars has prevented an analysis being made. In the larger individuals especially it is microperthitically intergrown with clear orthoclase. Microcline does not occur in the elæolite-sodalite type of pegmatite, but is common in the amphibole and quartz-bearing type and also occurs in the striking rock composed of blue sodalite, yellow cancrinite, and white microcline. In the Boharu mass there are prominent veins of elæolite-microcline pegmatite in which the microcline is micrographically intergrown with quartz and microperthitically with oligoclase.

Orthoclase is in subordinate amount to microcline, usually in clear and quite unweathered grains, untwinned, but showing cleavages intersecting at approximately right angles. Plagioclase, (chiefly albite and oligoclase) is an occasional constituent of the syenite, and is confined to the fine-grained groundmass.

Amphibole.

In the syenite amphibole occurs both as large crystals, usually ragged and not showing good crystal outlines, but with well developed prismatic cleavages, and as irregular aggregates of small individuals, associated with abundant sphene and apatite. In the pegmatites it forms veins and masses, often very coarsely crystalline, and fibrous aggregates.

Its pleochroism colours are: X=greyish-yellow, Y=blue-green and Z=blue-green; it is positive and dark-slow. The extinction angle, $Z \wedge c$, is 36° as a maximum of all observed sections, a common maximum being 24° to 27°. Hastingsite has extinction angles of 24° to 30°, katoporite (cataphorite) 31° to 58°, and basaltic hornblende has sometimes an extinction angle as high as 37°. The pleochroism colours agree with those of hastingsite[1], X=yellow-green, Y=deep blue-green, Z=deep blue-green; and with the basaltic hornblende from Beverley[2], X=greenish-yellow, Y=olive-green, Z=blue-green.

A detailed analysis of this amphibole (registered number 30-287) by W. A. K. Christie gives the following composition:—

	Per cent.
SiO_2	52·21
Al_2O_3	2·72
Fe_2O_3	2·71
FeO	17·19
MgO	11·24
CaO	10·89
Na_2O	1·04
K_2O	0·37
H_2O (below 107°C)	0·17
H_2O (above 107°C)	0·61
TiO_2	trace
MnO	0·59
F	0·35
	100·09
Less O	0·15
TOTAL	99·94

Dr. Christie has also determined its specific gravity ($\frac{30°}{4°}$), as 3·126 and its refractive indices, for sodium light, to be $\alpha=1{\cdot}631$, $\beta=1{\cdot}649$, $\gamma=1{\cdot}659$ (all $\pm$ ·003), and it is optically negative.

Comparing this with the undernoted analyses it will be seen that the Kishengarh mineral is too high in silica, lime and magnesia, and too low in alumina, soda and iron for hastingsite, and approaches much more closely analyses of hornblende. The alumina content, notably low for amphibole, is rather characteristic of the amphiboles of soda-syenites. It has not the characteristic reddish colour of katoforite, and its analysis shows deficiency of iron and soda, and excess in lime and magnesia, in comparison with that mineral. It may be identified as green hornblende with an unusually high extinction angle.

[1] *Mem., Geol. Surv. India,* XXX, pt. 3, p. 187.
[2] Iddings, "Rock Minerals," p. 351. (1906).

A. Kishengarh amphibole. (W. A. K. Christie.)
B. Hastingsite, nepheline-syenite, Dunganon, Ont. (B. J. Harrington.)[1]
C. Hornblende, granitic syenite, Donegal. (S. Haughton.)[2]
D. Hornblende, syenite, Biella. (A. Cossa.)[3]
E. Hornblende, dacite, Grenatilla.[4]
F. Hornblende, diorite, Faymont, Vosges. (A. Delesse.)[5]

	A.	B.	C.	D.	E.	F.
SiO_2 . .	52·21	34·18	47·25	46·22	45·76	41·99
Al_2O_3 . .	2·72	11·52	5·65	8·12	8·80	11·86
Fe_2O_3 . .	2·71	12·62	19·11	9·33	5·32	..
FeO . .	17·19	21·98	0·94	15·18	11·23	22·22
MgO . .	11·24	1·35	11·26	5·20	14·08	12·59
CaO . .	10·89	9·87	11·76	10·08	10·62	9·55
Na_2O . .	1·04	3·29	0·98	2·46	1·39	} 1·32
K_2O . .	0·37	2·29	1·04	1·23	0·26	
TiO_2 . .	Trace	1·53	..	1·08	1·43	..
MnO . .	0·59	0·63	1·70	..	0·57	..
H_2O . .	0·78	0·35	..	1·36	0·85	0·47
F . . .	0·35	..	..	..	..	..
Loss on ignition	..	..	..	1·36	0·85	0·47
Less O . .	0·15	..	..	..	..	..
	99·94	99·61	99·69	100·26	100·31	100·00

A bright green, faintly pleochroic pyroxene occurs as somewhat rounded grains in the syenite, but is not common. It is biaxial, and the extinction angle, $X \wedge c$, is about 40°, X = pale green or bright green, Y and

Pyroxene.

[1] F. D. Adams and A. D. Barlow, *Geol. Surv. Canada, Geol. ser.* 5, Mem. 6, 247, (1910).
[2] *Quart. Journ. Geol. Soc.*, 18, 416, (1862).
[3] F. Zambonini, *Zeits. f. Kryst.*, 40, 231, (1905).
[4] c f. Iddings, "Rock Minerals," 338, (1906).
[5] *Ann. des. Mines*, Ser. 4, 16, 359, (1849)

Z= yellow-green or yellow-brown. In one variety of pegmatite found south of Mandaoria large crystals of the same mineral are included in a matrix of elæolite, sodalite and microcline, in this case the extinction angle being 30°, and X= deep green, Y and Z= yellow-brown and yellow-green. It may be classified as ægirine-augite.

Garnet.

Several varieties of garnet occur. A yellowish-brown kind was seen in one microscope slide of the granitoid syenite, and melanite occurs in the dark basic bands in the banded syenite. The latter also is found in calcareous quartzite and felspar-biotite rock with calcite, the nature of which is doubtful, but which may be xenoliths or hybrid rocks. Brown garnet, resembling that associated with the monchiquite of Mount Girnar in Kathiawar occurs as veins in quartz.[1] Pale pink garnets are found in felspathic veins in the syenite, which are probably pegmatitic, associated with biotite, sphene, apatite and molybdenite (rare).

Sodalite.

Sodalite is present in two varieties, one of a beautiful blue colour, and the other colourless and transparent; some of the latter is of an evanescent pink tint when the rock is freshly broken. Both varieties occur interstitially in the elæolite-sodalite pegmatite, usually separating the large individuals of elæolite, and the colourless variety is often intimately mixed with fine granular elæolite.

Two analyses of the blue variety are appended, the first that quoted by E. Vredenburg, and the second made in the Geological Survey laboratory by B. C. Gupta on material collected by me.

	Per cent.
SiO_2	38·055
Al_2O_3	31·30
Fe_2O_3	trace.
CaO	0·001
Na_2O	24·77
Loss on ignition	0·82
Cl	7·18
SO_3	trace.
	102·126
Less oxygen equivalent of chlorine	1·618
TOTAL	100·508

	Per cent.
SiO_2	36·92
Al_2O_3	34·46
Fe_2O_3	trace.
MgO	0·17
CaO	*Nil.*
Na_2O	17·20
K_2O	5·37
H_2C	3·07
Cl	4·80
	101·99
Less oxygen equivalent of chlorine	1·08
TOTAL	100·91

[1] *Quart. Journ. Geol. Soc.*, LVII, (1901), pp. 38—54.

Cancrinite.

Cancrinite in small interstitial grains occurs in the syenite in the two most westerly outcrops, to the west of the Guest House. It is well to note that scapolite and cancrinite are indistinguishable in small grains in thin sections unless their prismatic cleavages (hexagonal, intersecting at 60° in the case of cancrinite and tetragonal intersecting at 90° in scapolite) are observed, as their other optical properties are identical. In view however of the abundance of cancrinite in the pegmatites, there is little doubt that it is this mineral which is present in the syenite proper and not scapolite.

In the pegmatites it occurs in large individuals, sometimes a foot across, without crystal outlines but with perfect prismatic cleavage. It is white or greenish white, translucent, with pearly lustre on the cleavage faces, and weathers with a chalk-like crust as elæolite does. Sometimes it is granular and yellow, and a very striking rock is that in which this variety is associated with blue sodalite and felspars. Black biotite commonly accompanies it.

Calcite.

Calcite has been detected in interstitial grains among the felspars of the syenite, occurring in the same way as cancrinite. Calcite occurs as an original constituent in both the Sivamalai and Vizagapatam syenites[1], and must here also be regarded as primary.

Thulite (manganese zoisite).

The pink mineral occurring as fibrous patches in the cancrinite-calcite contact rock near Mandaoria has presented considerable difficulty in determination, as it belongs to a group, the zoisites and epidotes, which are on the boundary line between the orthorhombic and monoclinic systems, and the species of which are optically very variable and frequently anomalous, and grade rather indefinitely into each other. Macroscopically it is rose-pink or pale yellowish-pink and in thin sections colourless or pale pink, in the latter case being pleochroic from pink to colourless. The specific gravity of a piece, probably slightly admixed with calcite was determined as 3·27 by weighing, and of an isolated fragment by heavy liquids as 3·30. The specific gravity of zoisite is 3·25—3·37. The refractive index β was determined by my colleague, Dr. W. A. K. Christie, as $1{\cdot}711 \pm {\cdot}002$ and $1{\cdot}700 \pm {\cdot}002$, on two different specimens, $1{\cdot}702 \pm {\cdot}002$ being obtained from thulite

[1] *Rec., Geol. Surv. Ind.*, XXXVI, p. 20, (1908).
Mem., Geol. Surv. Ind., XXX, pp. 197 and 214, (1900).

from Lerviken, Norway, that given for normal zoisite being 1·699—1·720 by Luquer, 1·696—1·7058 by Iddings and 1·697—1·702 by Weinschenk and Clark. It is probably biaxial with large optic axial angle; the plane of the optic axes is perpendicular to the cleavage and the longitudinal section of the crystals shows the emergence of an optic axis. In the rock the mineral occurs as granular aggregates and felted bundles of prismatic crystals, the elongation of which is in the direction of the *c* axis. The pinacoidal cleavage, parallel to (010), is perfect, and the extinction is parallel to this cleavage; there are also two indistinct partings mutually at right angles and 45° to the cleavage direction. The double refraction is very low and the interference colours are anomalous, indigo and yellow. Twinning is frequent, the twinning plane making an angle of about 66° with the traces of the cleavage in transverse sections of the crystals, in which sections the angle between the cleavage traces and the extinction direction is 15°—18°.

An analysis of the mineral, by B. C. Gupta, is given below, with analyses of withamite (manganese epidote) and thulite, and the theoretical composition of zoisite for comparison.

—	Kishengarh mineral	Withamite.[1]	Thulite.[2]	Theoretical zoisite.
SiO_2	34·92	43·23	42·81	39·7 per cent.
Al_2O_3	33·17	23·09	31·14	33·7 ,,
Fe_2O_3	5·99	6·68	2·29	
FeO	..	1·13	..	
MgO	0·49	0·88	..	
CaO	24·43	20·00	18·73	24·6 ,,
Na_2O	0·14	0·94	1·89	
K_2O	..	0·96	..	
H_2O	..	2·40	0·64	2·0 ,,
MnO	0·86	0·14	Mn_2O_3 1·63	
Li_2O	..	0·25	..	
Insol.	..	0·35	..	
TOTAL .	100·0	99·70	100·76	100·0 per cent.

It will be seen that the analysis agrees fairly well with that of thulite and with the theoretical composition of zoisite, except that the percentage of silica is somewhat low.

[1] Heddle, *Min. Mag.*, 5, 15, (1882).
[2] Gmelin, *Poggendorff's Annalen*, 49, p. 539, (1840).

EXPLANATION OF PLATES.

PLATE 2.—FIG. 1.—Granitoid syenite, main intrusion.
FIG. 2.—Foliated syenite, near Mandaoria.

„ 3.—FIG. 1.—Banded syenite.
FIG. 2.— „ „ , showing contortion.

„ 4.—FIG. 1.—Photomicrograph of granitoid syenite; × 18.
FIG. 2.—Photomicrograph of granitoid syenite; polarized light; × 18.

„ 5.—FIG. 1.—Photomicrograph of granitoid syenite; × 18.
FIG. 2.—Photomicrograph of banded syenite; × 18.

„ 6.—FIG. 1.—Photomicrograph of banded, biotitic syenite; × 18.
FIG. 2.—Photomicrograph of fine-grained, foliated syenite; × 18.

„ 7.—FIG. 1.—Photomicrograph of ægirine-pegmatite; × 18.
FIG. 2.—Photomicrograph of amphibole-garnet-pegmatite; × 18.

„ 8.—FIG. 1.—Photomicrograph of sodalite in elæolite-sodalite rock; × 18.
FIG. 2.—Photomicrograph of xenolith with biotite, pyroxene and sphene; × 18.

„ 9.—FIG. 1.—Photomicrograph of thulite-cancrinite-calcite rock; × 18.
FIG. 2.—Photomicrograph of thulite-tremolite-felspar rock; × 18.

„ 10.—FIG. 1.—Photomicrograph of thulite-tremolite rock; × 18.
FIG. 2.—Photomicrograph of thulite-calcite rock; × 18.

„ 11.—FIG. 1.—Photomicrograph of impure crystalline limestone; × 18

„ 12.—Geological map of part of Kishengarh; scale 1″=1 mile.

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GRANITOID VARIETY OF SYENITE,
Showing characteristic weathering, main intrusion, near road.

A. M. Heron, Photos. *G. S. I. Calcutta.*

FOLIATED VARIETY OF SYENITE, SOUTH OF MANDAORIA.

BANDED VARIETY OF SYENITE, west of Guest House.

A. M. Heron, Photos.

G. S. I. Calcutta.

BANDED VARIETY OF SYENITE,
Showing contortion of layers, west of Guest House.

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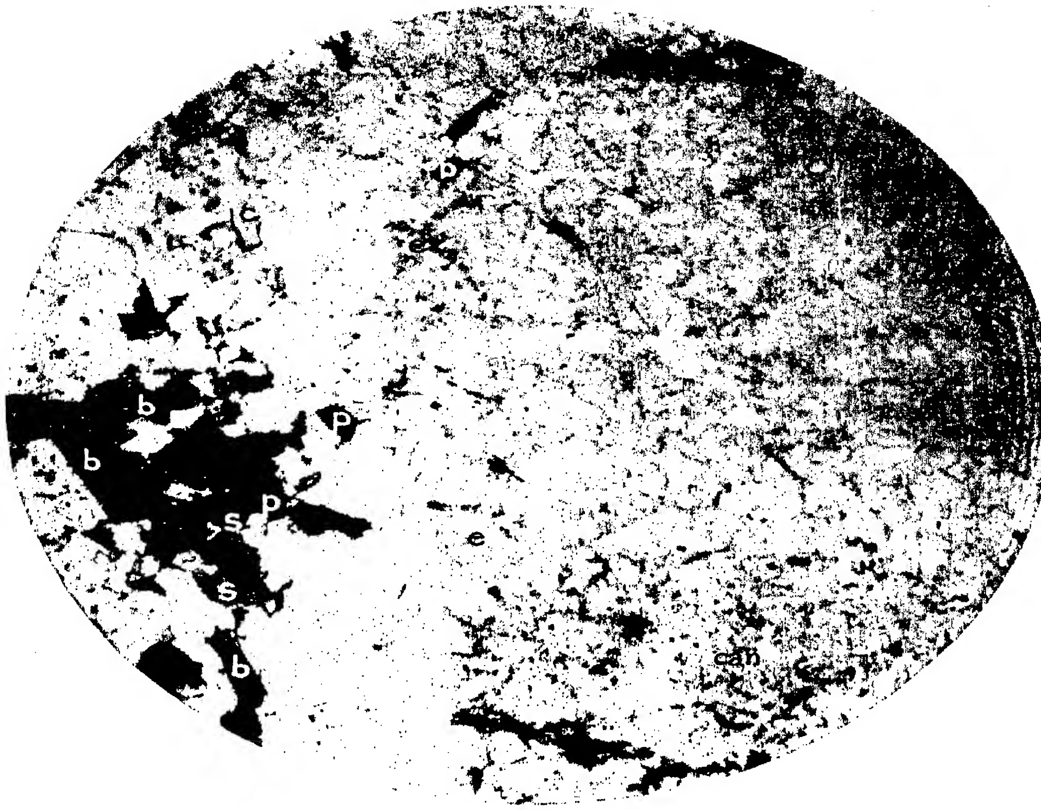
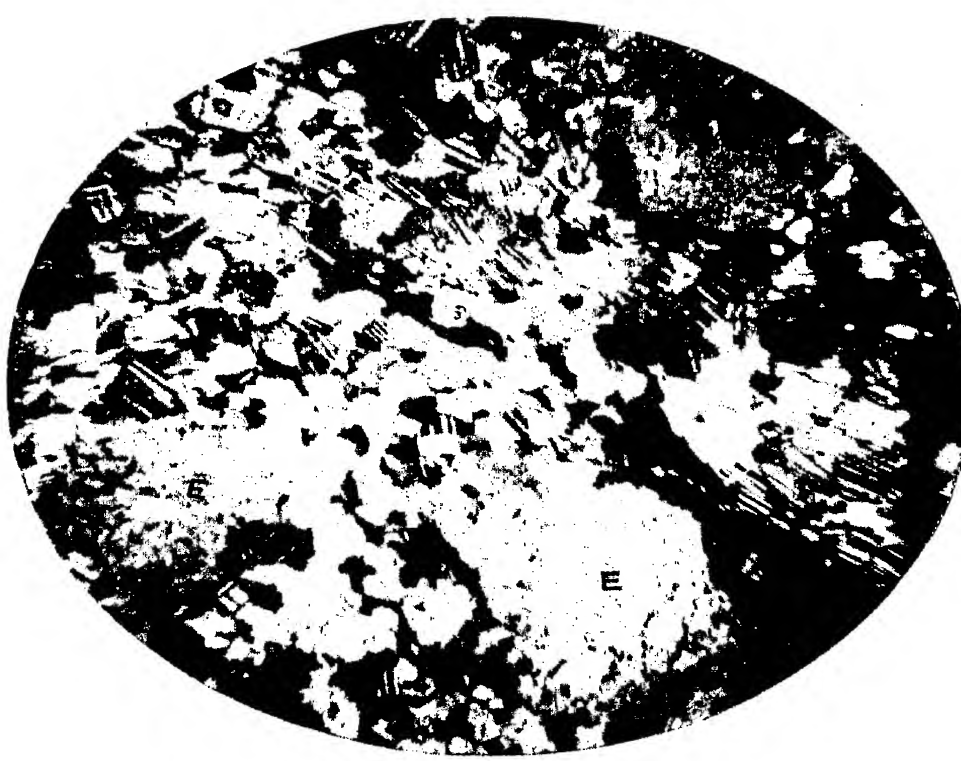


FIG. 1. NORMAL GRANITOID VARIETY OF SYENITE. × 18.
s—sphene. b—biotite. c—calcite. m—microcline. e—elæolite. p—pyroxene.
can—granular cancrinite. Remainder of slide mainly microcline and other felspars.



A. M. Heron, Photos. *G. S. I. Calcutta.*

FIG. 2. GRANITOID VARIETY OF SYENITE, UNDER CROSSED NICOLS, × 18.
showing phenocrysts of elæolite E in mosaic of microcline, plagioclase and orthoclase, with amphibole (dark.)

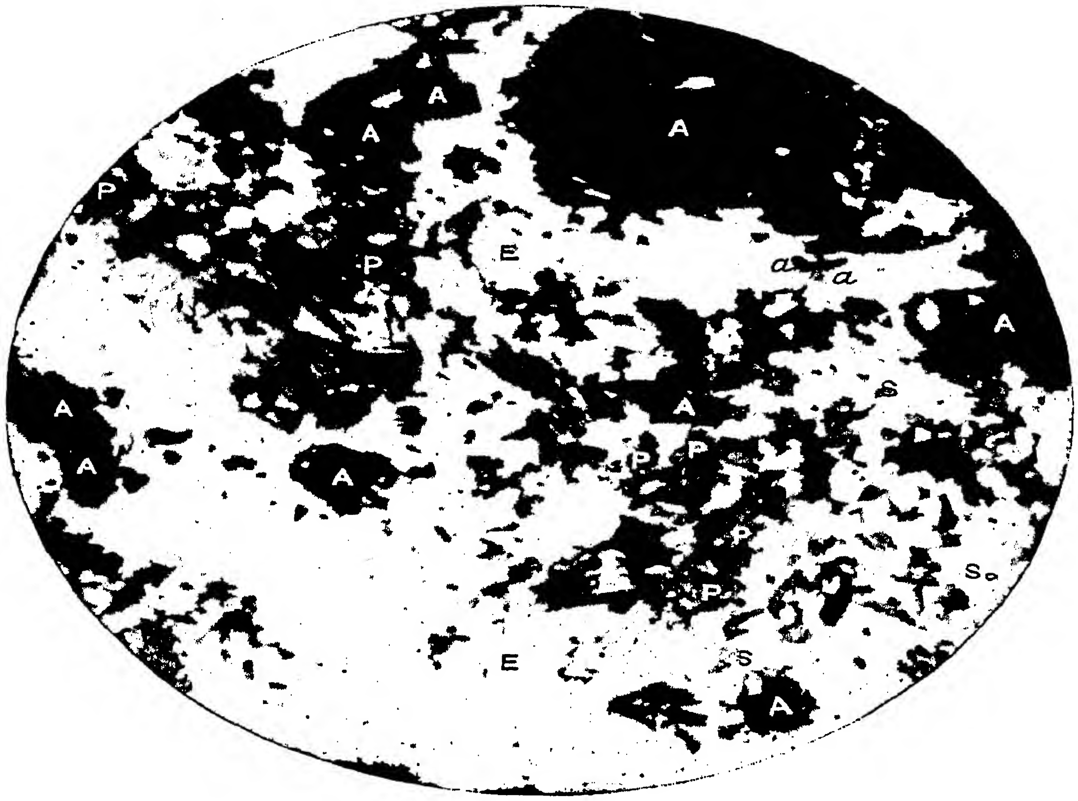
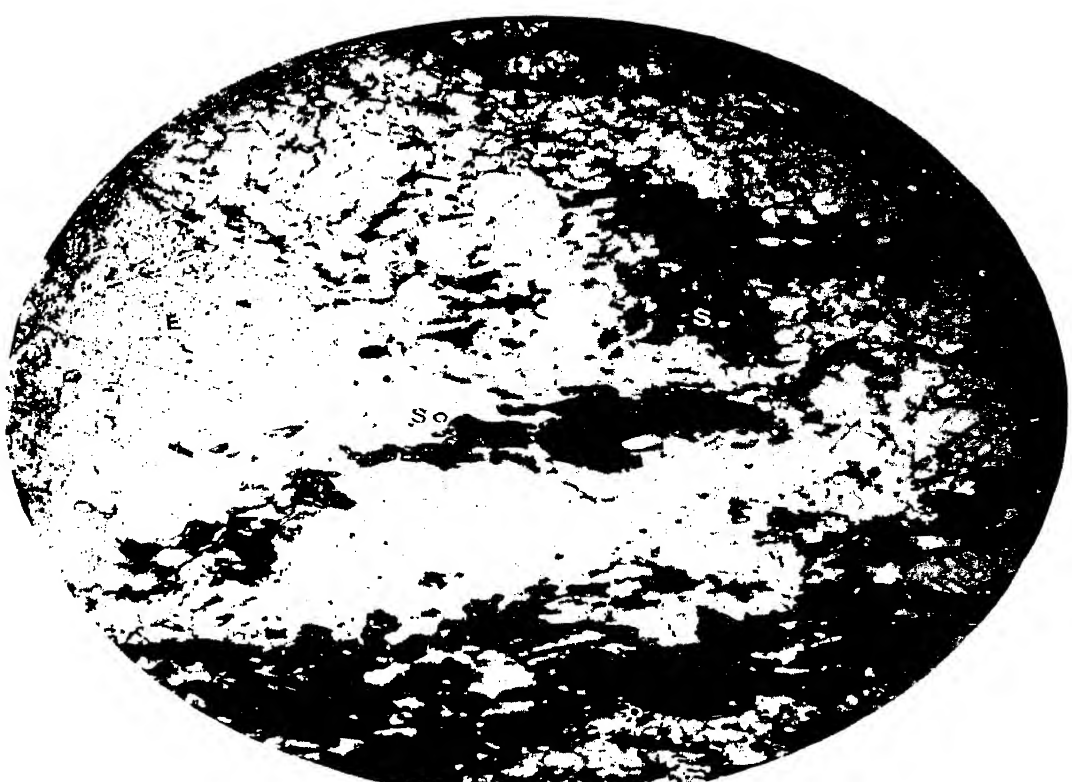


FIG. 1. GRANITOID VARIETY OF SYENITE, WITH MORE FERROMAGNESIAN MINERALS THAN IS USUAL.

A—amphibole. E—elæolite. P—pyroxene. S—sphene. *a*—apatite. So—sodalite.



A. M. Heron, Photos. *G. S. I. Calcutta.*

FIG. 2. BANDED TYPE OF SYENITE.

E—elæolite. So—sodalite. S—sphene. pale portion of slide—felspars, dark portion—aggregate of biotite and pyroxene.

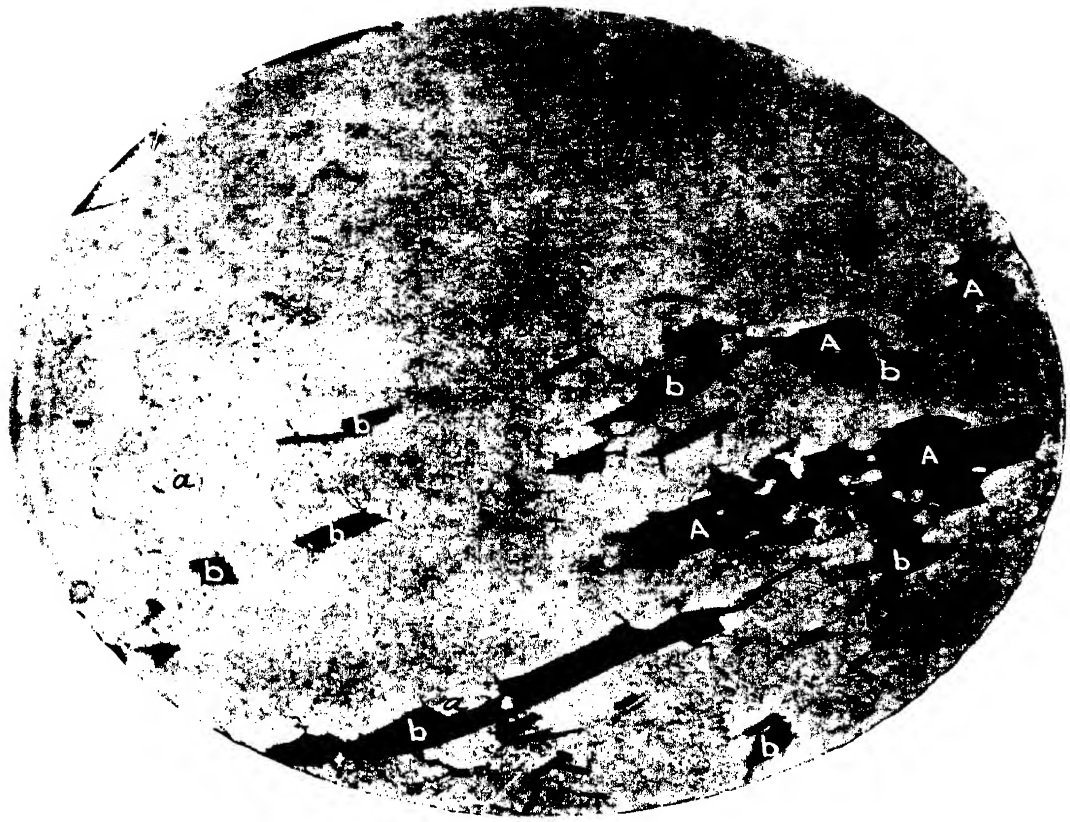
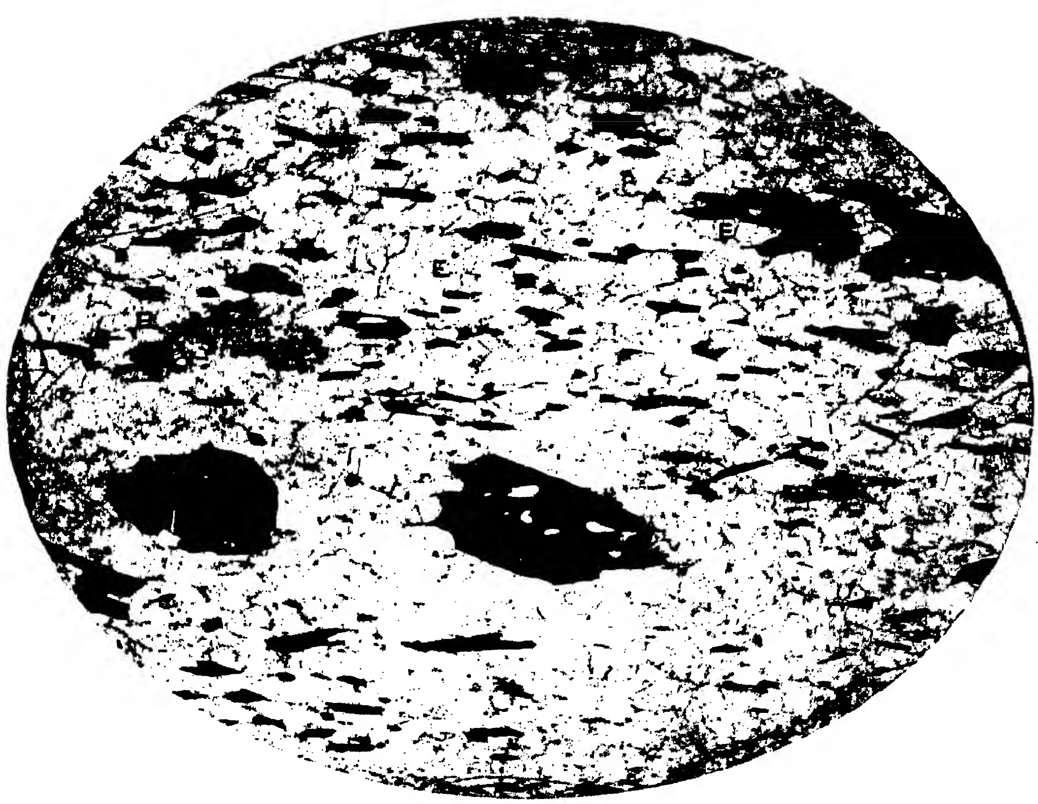


FIG. 1. BANDED BIOTITE VARIETY OF SYENITE.

A—amphibole. a—apatite. b—biotite. Remainder of slide—elæolite and microcline.



A. M. Heron, Photos. *G. S. I. Calcutta*

FIG. 2. FINE-GRAINED FOLIATED SYENITE.

E—elæolite. Dark mineral—amphibole. Pale portion of slide—felspar and elæolite aggregate.

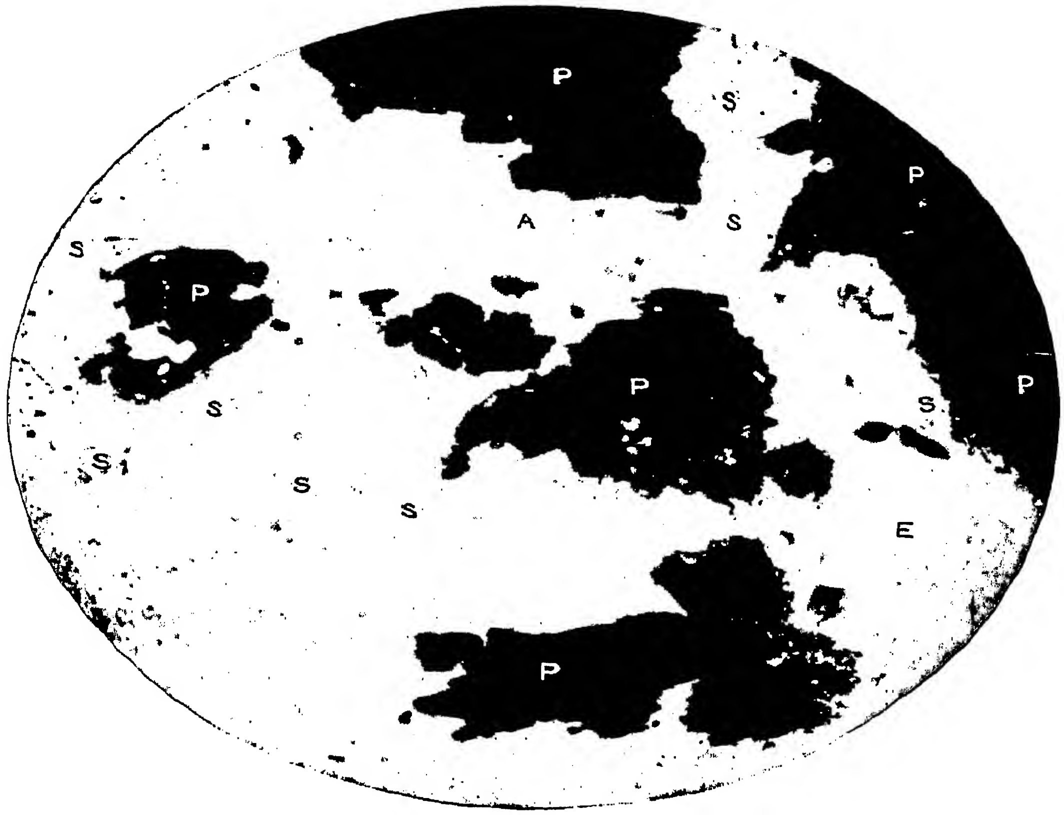
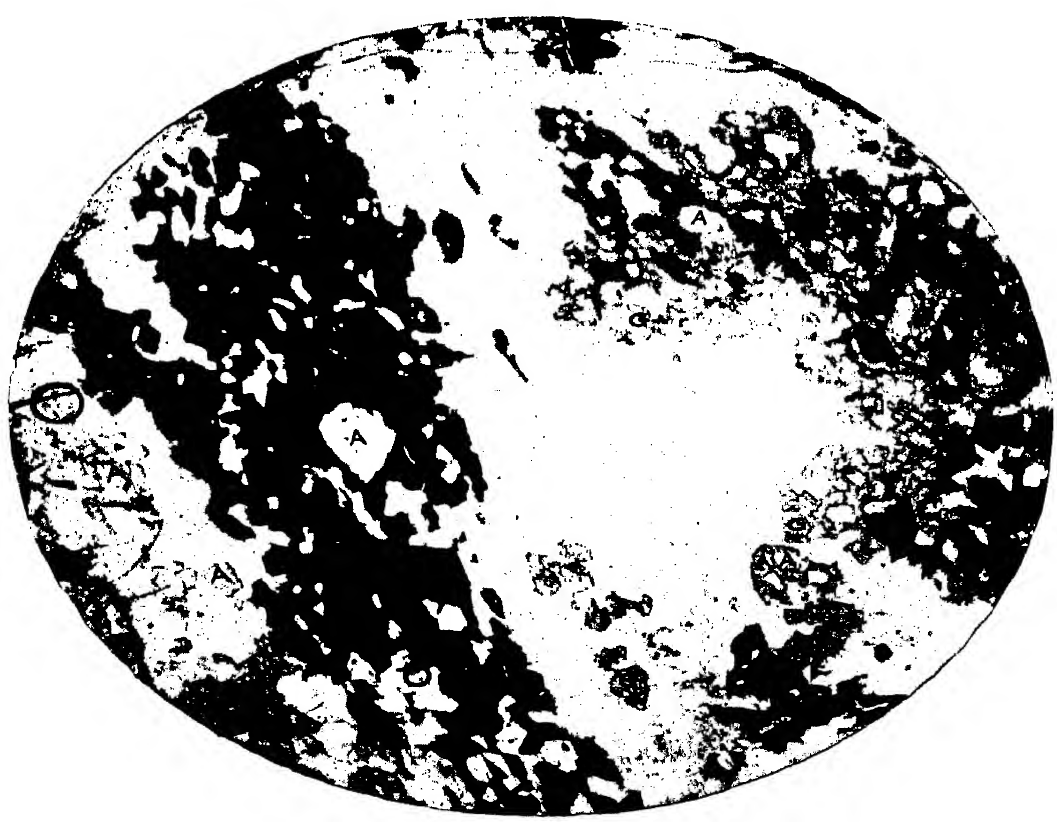


FIG. 1. ÆGIRINE PEGMATITE. × 18.
A—apatite. P—pyroxene (ægirine.) S—sodalite. E—elæolite
Pale portion of slide—microcline and other felspars.



A. M. Heron, Photos. *G. S. I. Calcutta.*

FIG. 2. AMPHIBOLE AND GARNET-BEARING PEGMATITE. × 18.
A—apatite. G—garnet. Dark mineral—amphibole. White mineral—felspar.

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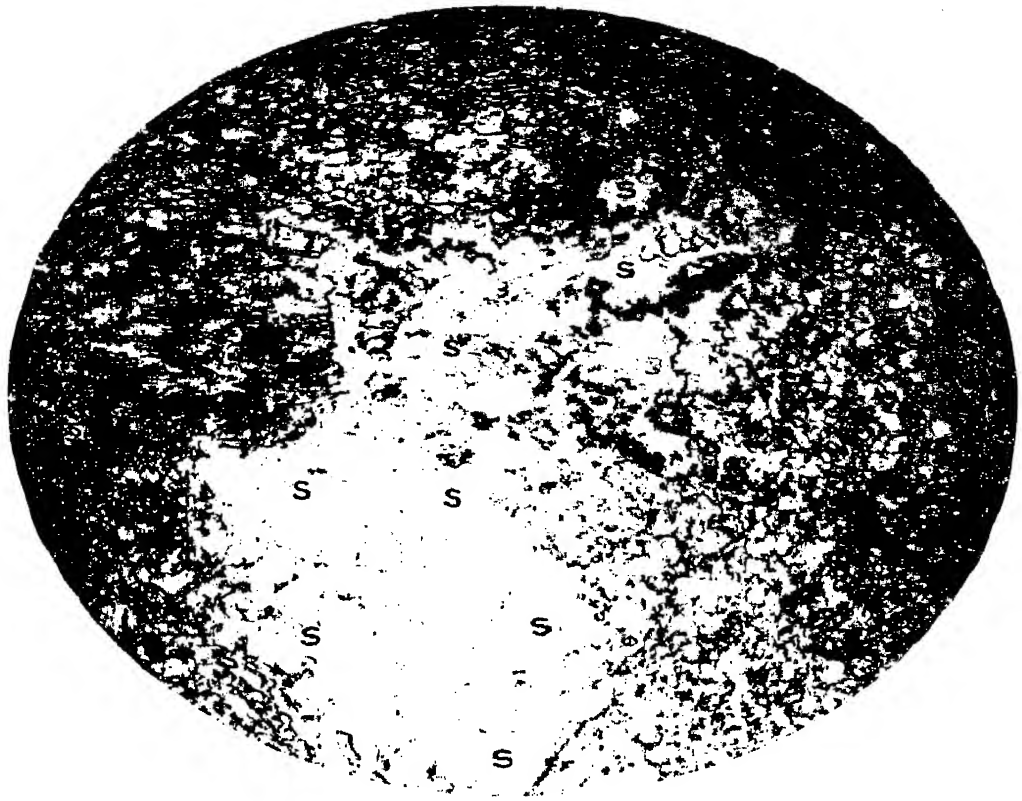
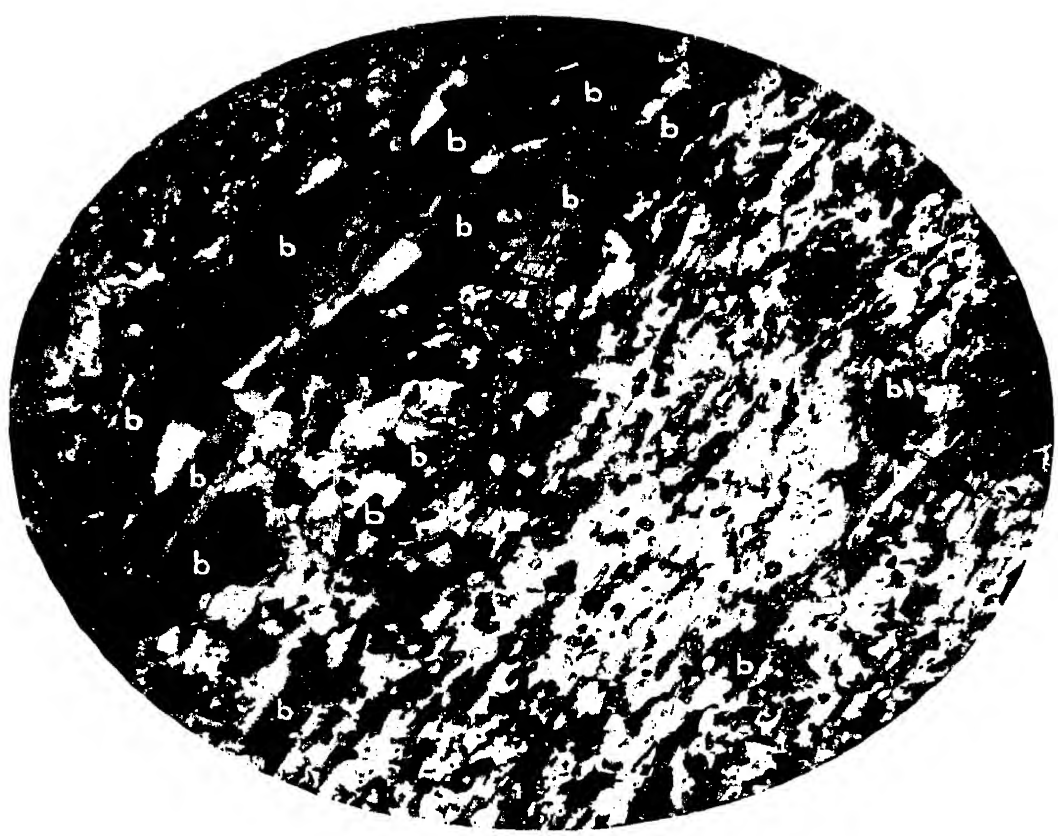


FIG. 1. SODALITE VEIN (S), IN GRANULAR ELÆOLITE SODALITE ROCK. × 18.



A. M. Heron, Photos. *G. S. I. Calcutta.*

FIG. 2. BASIC PATCH OR XENOLITH, RICH IN BIOTITE, PYROXENE AND SPHENE. × 18.
Biotite (b) pyroxene and sphene granules, in felspar aggregate.

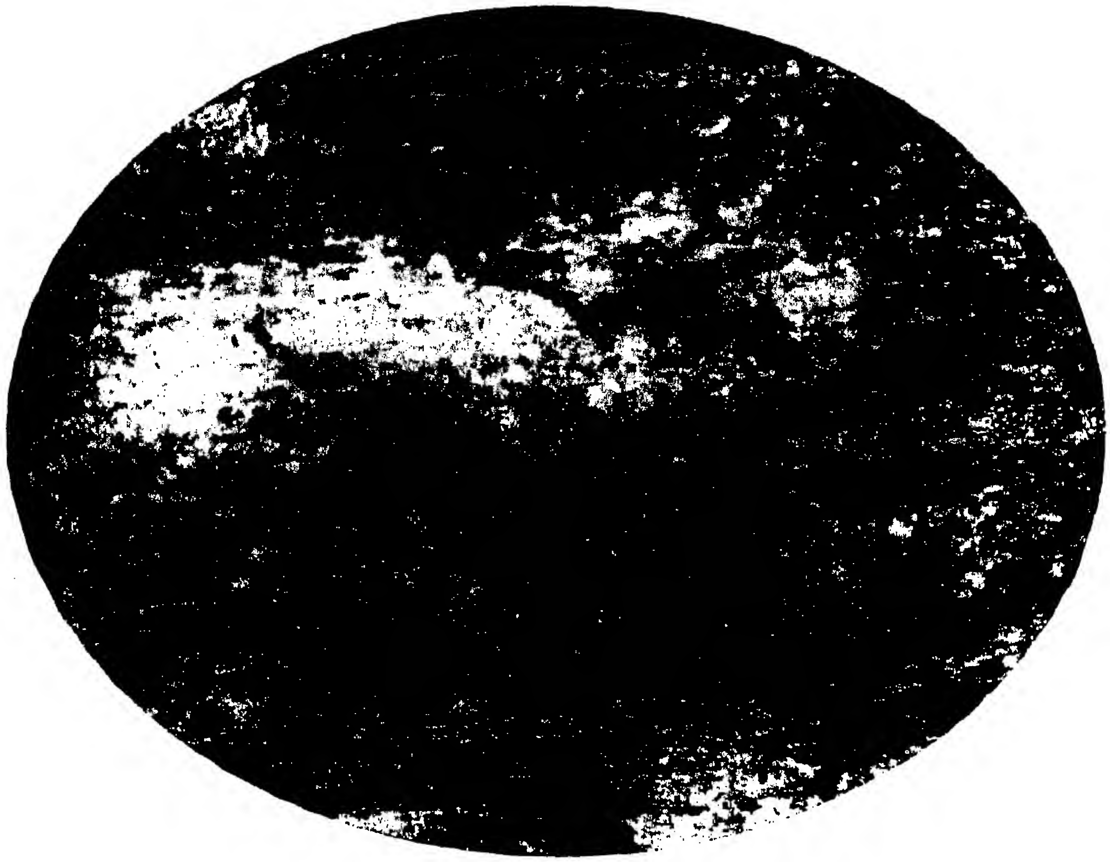
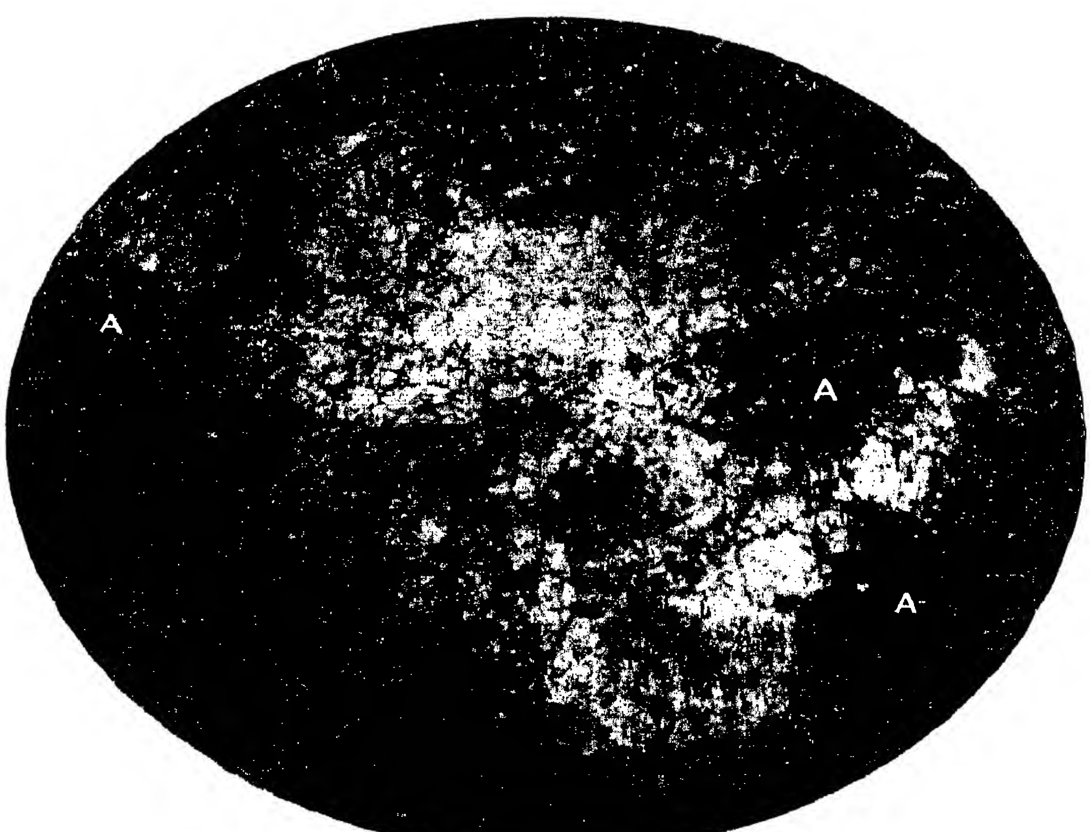
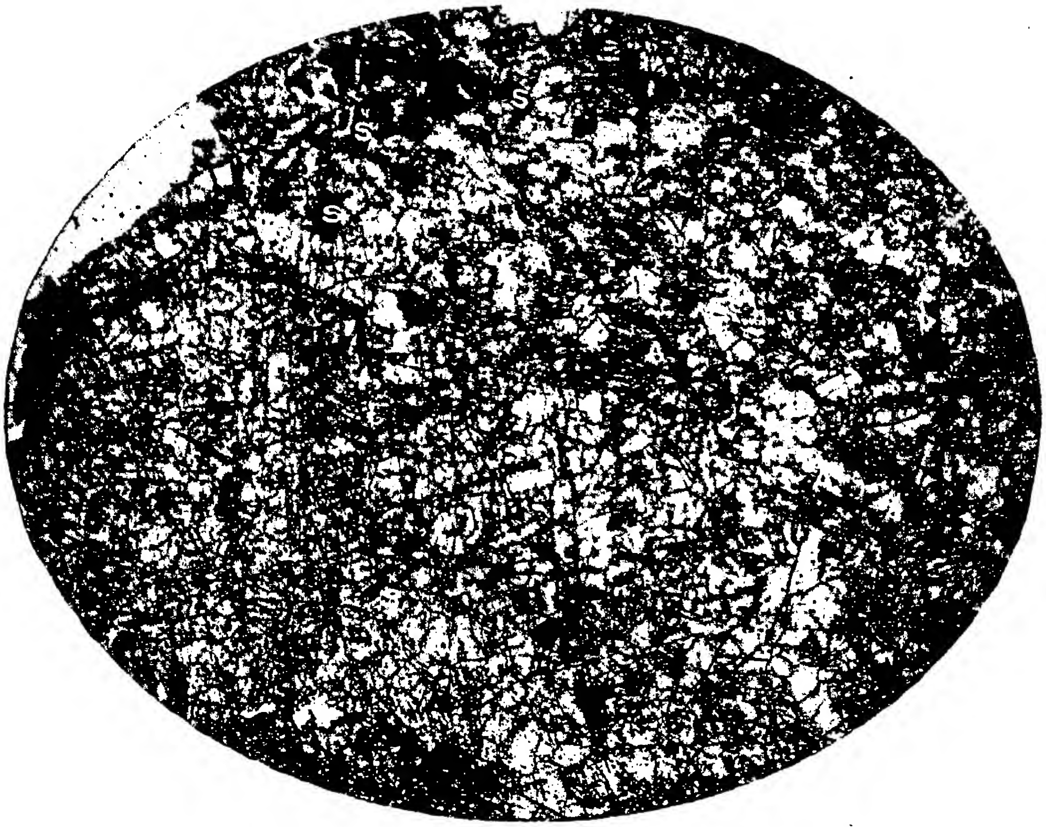


FIG. 1. THULITE-CANCRINITE-CALCITE ROCK.
Thulite (dark) with calcite and cancrinite.



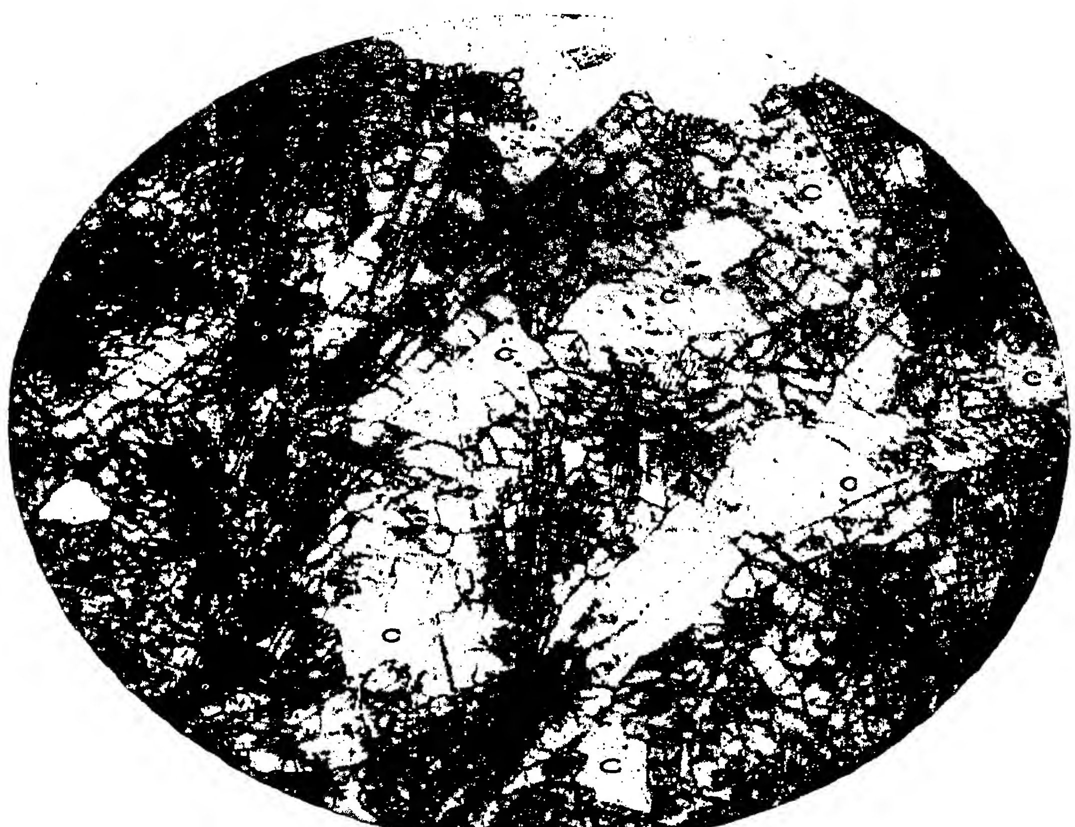
A. M. Heron, Photos. *G. S. I. Calcutta.*

FIG. 2. THULITE-TREMOLITE-FELSPAR ROCK
A—Amphibole (tremolite). Z—Thulite. Pale material mainly albite.



THULITE-TREMOLITE ROCK.

A -Thulite with amphibole (tremolite). S—Grains of sphene



A. M. Heron, Photos. *G. S. I. Calcutta.*

THULITE-CALCITE ROCK.

Thulite in calcite. C—Calcite.

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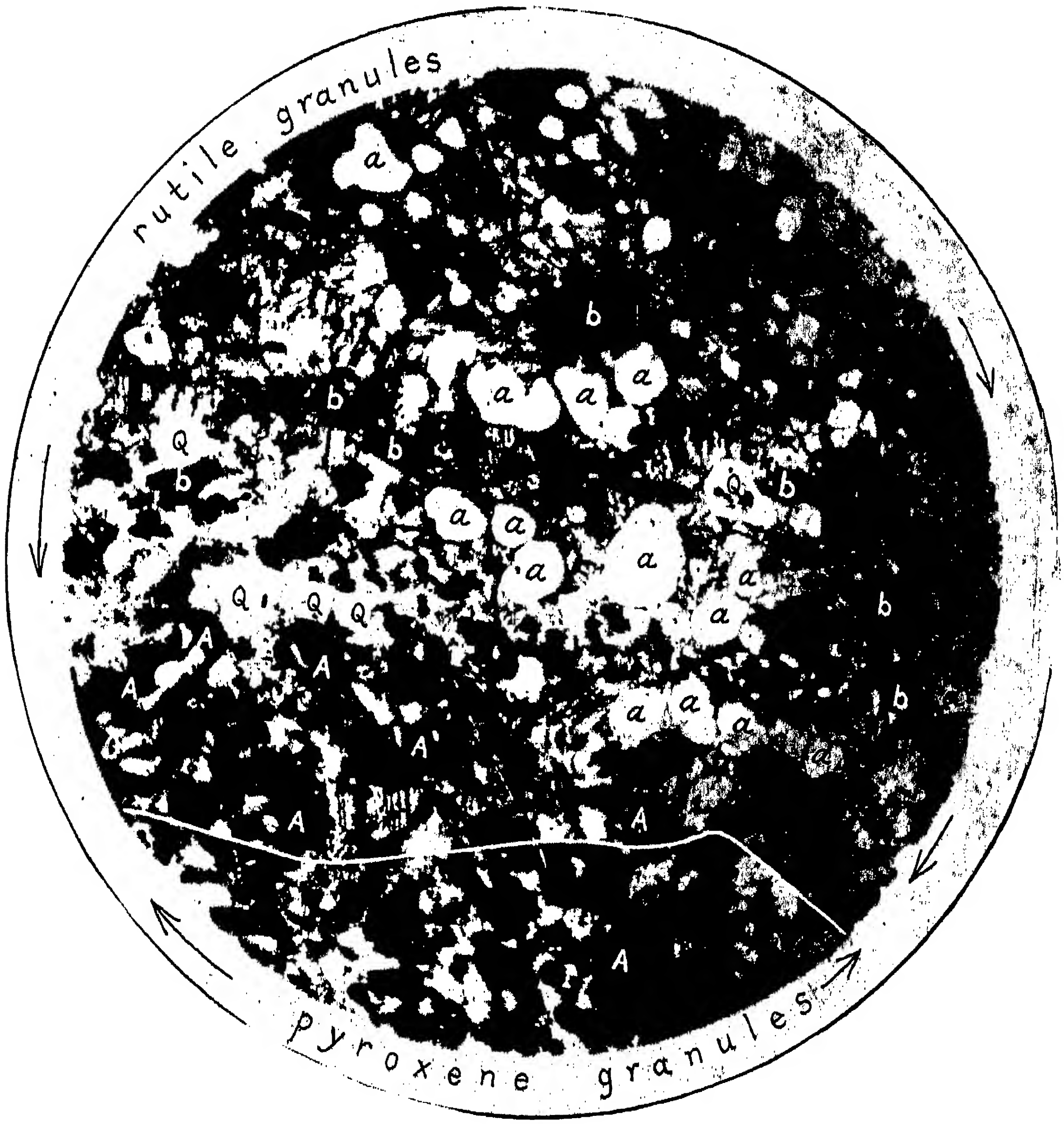

A. M. Heron, Photos. *G. S. I. Calcutta.*

IMPURE CRYSTALLINE DOLOMITE. × 18.

A—amphibole. a—apatite. b—biotite. Q—quartz. Dark granules in upper portion of slide are rutile, in lower portion pyroxene, interstitial material is calcite.

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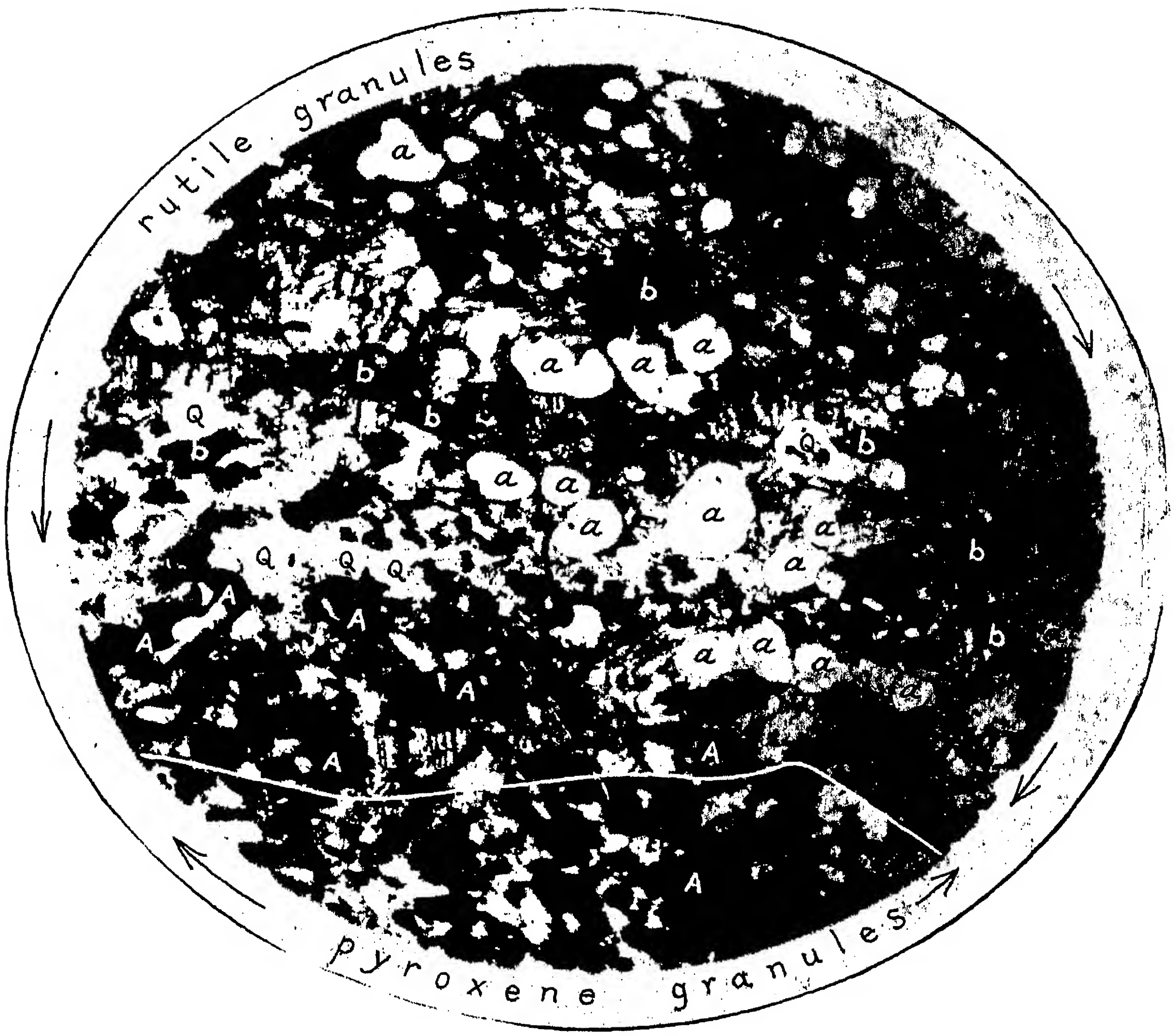
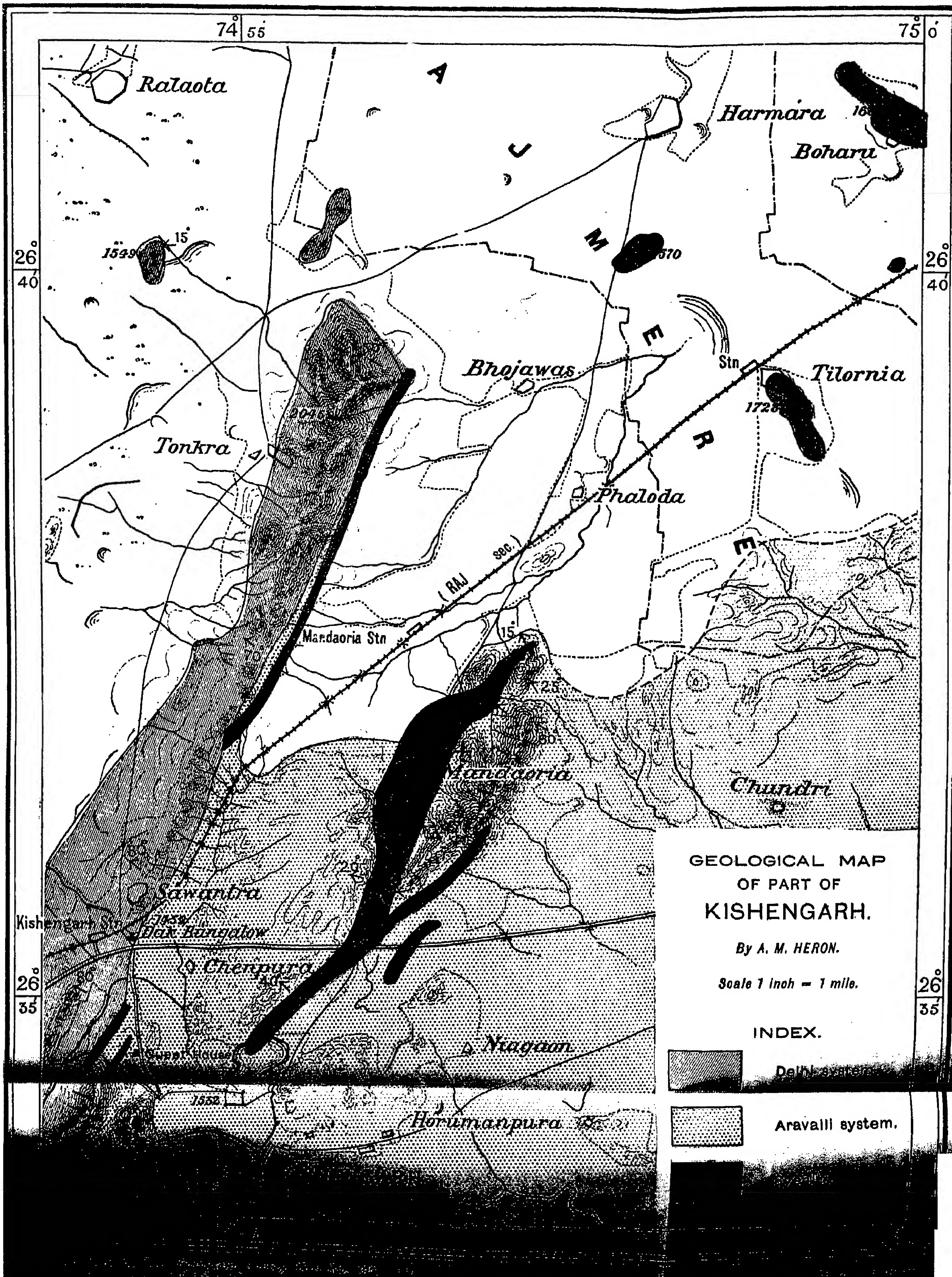


A. M. Heron, Photos. G. S. I. Calcutta.

IMPURE CRYSTALLINE DOLOMITE. × 18.

A—amphibole. a—apatite. b—biotite. Q—quartz. Dark granules in upper portion of slide are rutile, in lower portion pyroxene, interstitial material is calcite.


74° 55
75° 0'
26° 40'
26° 35'
AJMER
MERWARA
Rataota
Harmara
Boharu
Bhojawas
Tilornia
Stn
Tonkra
Phaloda
(RAJ sec.)
Mandaoria Stn
Mandaoria
Chundri
Sawantra
Kishengarh Stn
Dak Bangalow
Chenpura
Supdt House
Nagaon
Horumanpura
1549
1725
GEOLOGICAL MAP
OF PART OF
KISHENGARH.
By A. M. HERON.
Scale 1 inch = 1 mile.
INDEX.
Delhi system
Aravalli system.

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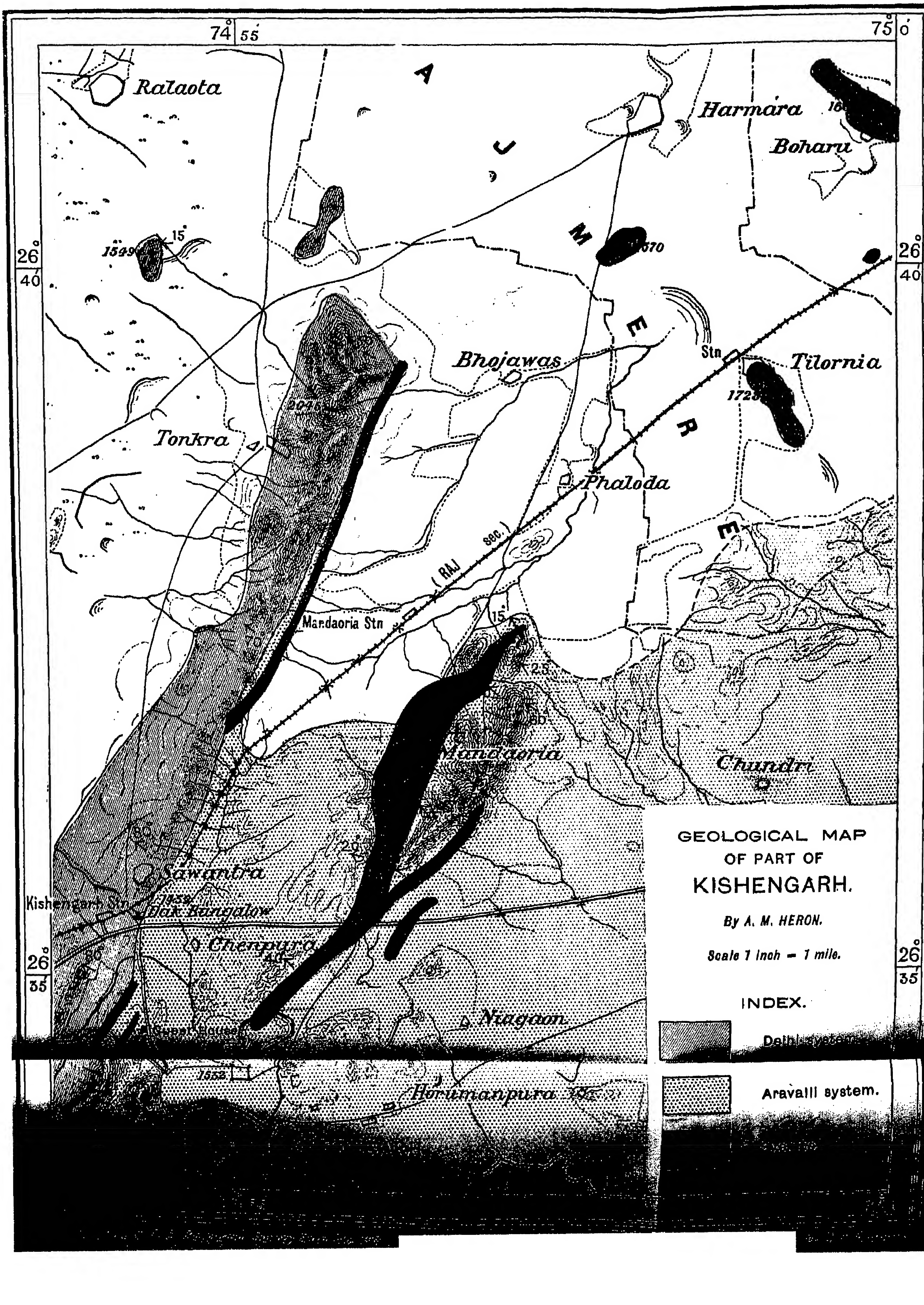


RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1925 **[February.**

GYROLITE AND OKENITE FROM BOMBAY. BY W. A. K. CHRISTIE, B.SC., PH.D., M.INST.M.M., *Chemist, Geological Survey of India.* (With Plate 13.)

THE minerals discussed in this paper, although not represented until recently in the collections of the Geological Survey, have both been recorded before from India.[1] Doubts have recently been thrown on the authenticity of many of the specimens of okenite in European collections [2] and the distinctive nature of the much rarer mineral gyrolite and its near relatives as mineral species has often been called in question.[3] It may therefore be worth while to describe the new acquisitions of these non-aluminous zeolites.

GYROLITE.

In an unnamed collection of minerals from the Deccan Trap of Bombay Island, acquired in 1922 by purchase from Mr. J. Ribeiro, there is a small specimen of gyrolite from Nowroji Hill [4] (19° 57′ 72° 53′). It occurs as a mammillary aggregate, the roughly hemispherical parts of which vary in diameter from 0·5 to 1 cm. The surface has a delicately chiselled appearance reminiscent of the manner in which hair is represented in sculpture. The nodules on

[1] Gyrolite from Poona: M. F. Heddle, *Mineral Mag.*, VIII, 199, (1889); F. Cornu, *Mineral. Mitth.*, XXV, 515, (1906) and *Sitz. K. Akad. Wiss. Wien*, CXVI, Abt. 1, 1235, (1907). Cornu gives a partial analysis. Okenite from Poona: S. Haughton, *Journ. Geol. Soc. Dublin*, II, 114, (1868), with an analysis.

[2] O. B. Boggild, *Danske Vidensk. Selskab. Math.-fys. Meddeleser*, IV, part 8, 1, (1922).

[3] *Cf.* F. Cornu, loc cit.

[4] *Cf.* map, *Rec., Geol. Surv. Ind.*, LIV, Plate 4, (1922).

fracture show a series of irregularly overlapping plates, producing a radiate structure. The mineral has a perfect platy cleavage, thin laminæ being flexible but not elastic. The hardness is about 3. The specific gravity is 2·388-2·390 (acetylene tetrabromide and xylol, $\frac{28°}{28°}$C.). The lustre on the yellowish white, mammillary surface is dull, on the cleavage faces pearly and shining. The cleavage flakes are transparent to translucent.

The mineral is uniaxial; cleavage plates sometimes, however, show the emergence of two axes with a very small axial angle. It is optically negative. For sodium light $\omega = 1·549 \pm ·001$, $\varepsilon = 1·536 \pm ·002$ (embedding method with mixtures of cinnamon and clove oils, controlled with an Abbe refractometer).

Its composition is as follows :—

SiO_2	52·09
Al_2O_3	0·49
MgO	0·29
CaO	33·07
SrO	0·05
Na_2O	0·51
K_2O	0·01
H_2O below 107°C	2·99
H_2O above 107°C	10·36
	99·86

It contains no fluorine. The composition is in reasonable agreement with the original formula of T. Anderson,[1] 2 CaO, 3 SiO_2, 3 H_2O, with SiO_2 52·12 per cent., CaO 32·31 per cent. and H_2O 15·57 per cent.; it is somewhat nearer to that of F. W. Clarke,[2] $Ca_4(Si_2O_7)_3H_{10}$, with SiO_2 53·51 per cent., CaO 33·17 per cent. and H_2O 13·32 per cent.

O. B. Boggild[3] has determined gyrolite as tri-rhombohedral, although it appears that the material on which alone measurements were possible is held by F. Cornu and A. Himmelbauer[4] to be a distinct mineral, reyerite. My attempts to ascertain the symmetry from percussion and etched figures on cleavage plates were unsuccessful.

[1] *Phil. Mag.*, 4th Ser., I, 113, (1851).
[2] *Bull. U. S. Geol. Surv*, DLXXXVIII, 108, (1914).
[3] Author's abstract in *Zeits. f. Kryst.*, XLVIII, 534, (1911), from *Meddelelser om Grønland*, 34, 91 et. seq., (1908).
[4] *Mineral. Mitth.*, XXV, 519, (1906) and A. Himmelbauer in C. Doelter. Handbuch der Mineralchemie, II, 471, (Dresden, 1914).

The double refraction is considerably higher than the only value previously recorded,[1] ·0055 (ω=1·5645, ϵ=1·5590), but there again the determination was apparently on reyerite of Cornu and Himmelbauer, who give for that mineral ω=1·564 and an analysis resembling that of Boggild's material. Himmelbauer gives values of ω for gyrolite varying from 1·540 to 1·548.

The gyrolite occurs with calcite, apophyllite and okenite. The calcite gives one the impression of having been the first to crystallize, gyrolite nodules being attached to plane crystal faces. Thin sections from other parts of the specimen, however, show this apparently abnormal sequence[2] to be illusory; there calcite is seen to be enveloping and replacing gyrolite. Projecting from the gyrolite nodules and later than them are many crystals of apophyllite (ϵ 1·536 $\pm$·001, positive), showing (100), (001) and (111), some of them double-ended, attached by a prism face. Likewise later than the gyrolite and perched on the top of it are three little tufts of fibrous okenite, between 2 and 3 mm. in diameter and very similar to that described below. The fine projecting spicules have straight extinction, positive elongation and η about 1·541. In one instance okenite spicules are seen penetrating and included in a crystal of apophyllite. The order of crystallization was probably gyrolite, okenite and apophyllite, calcite.

OKENITE.

The beautiful specimens of this mineral here described were collected by Dr. C. S. Fox in 1921 in a quarry in the Deccan Trap at the north-eastern foot of Golangi Hill[3] (19° 0′; 72° 54′) on Bombay Island. The okenite occurs with other zeolites in large geodes in somewhat soft, green basalt, probably intrusive at a horizon of intertrappean, carbonaceous shales.

It occurs as an aggregate of fibrous, radiate nodules up to 3 cm. in diameter, whose mammillary surfaces have a delicate, furry covering of prismatic crystals of the same mineral, the furry spicules being up to 1·5 mm. in length and varying in thickness from 0·001 mm. to 0·02 mm. The delicate fibres forming the bulk of the nodules show a general radiate arrangement, although the fibres

[1] Boggild, loc. cit.

[2] *Cf.* C. N. Fenner, *Ann. N. Y. Acad. Sci.*, XX, 175, (1910) and T. L. Walker and A. L. Parsons, *Univ. Toronto Studies*, Geol. Ser., No. 14, 29, (1922).

[3] *Cf.* map, *Rec. Geol. Surv. Ind.*, LIV, Pl. 4, (1922).

are usually finely interlaced. This interlocking probably accounts for the toughness of the nodules; the inner surfaces of broken nodules, however, can be disintegrated easily with the finger nail. The fibrous material is pure white and opaque, with a pearly lustre. The tiny prismatic crystals are lath-shaped and often longitudinally striated; they are colourless and transparent. When gently rubbed between two glass surfaces they show a perfect longitudinal cleavage and signs of a transverse one approximately at right angles to this. The specific gravity of the fibrous material is 2·302 $(\frac{30^\circ}{4^\circ})$, (specific gravity bottle and vacuum). The refractive index of the lath-shaped crystals is 1·540 in one direction of extinction and 1·542 with the lower nicol rotated through 90°—determined in mixtures of clove and cinnamon oils at 30°C. in sodium light and controlled with an Abbe refractometer. They have apparently straight extinction, but individual spicules are so thin that an obliquity of several degrees would not be observable. The elongation is positive.

The fibrous material has the following composition.[1]

		Molecular ratios.		Calculated.
SiO_2	53·88		·894	·940
Al_2O_3	0·08			
Fe_2O_3	0·01			
CaO	27·61	·492	·498	·470
SrO	0·27	·003		
K_2O	0·06	·001		
Na_2O	0·12	·002		
H_2O, below 106°C.	6·36		1·000	·940
H_2O, above 106° C.,	11·66			
	100·05			

It contains no fluorine. The SiO_2 is about 3 per cent. low, RO is about 1½ per cent. high and H_2O about 1 per cent. high compared with the theoretical composition of okenite of the accepted formula CaO, 2 SiO_2, 2 H_2O, with 56·70 per cent. of SiO_2, 26·36 per cent. of CaO and 16·94 per cent. of H_2O.

The other minerals present are apophyllite and laumontite (see Pl. 13, fig. 2). The apophyllite is in well developed crystals up to 1·5 cm. square, showing (100), usually striated, (111) and (001). The laumontite is rather weathered and extremely friable. It has a good prismatic

[1] I am indebted to Professor A. Lacroix for permission to make this analysis in his laboratory in the Muséum national d'Histoire naturelle, Paris.

cleavage and the characteristic $(\bar{2}01)$ cleavage. $\eta\beta$ for sodium light is about 1·515[1]; the optical character is negative. The paragenesis is not easy to determine. In thin sections[2] the okenite fibres are seen penetrating the apophyllite and certainly seem to be replacing it. Again, idiomorphic apophyllites, jutting out of okenite nodules are seen, when the surrounding okenite is removed, to have lost their idiomorphic character wherever the two minerals are in contact,—and often the contact persists to the centre of the okenite spherules. There is, however, just as definite evidence against growth by replacement; in a cavity protected from abrasion is a small apophyllite crystal with uncorroded prism, pyramid and basal plane faces, from which project scores of undoubted okenite spicules, firmly attached, showing at any rate that the growth of okenite was not incompatible with the persistence of unaltered apophyllite (see Pl. 13, fig. 3); while on another specimen from Nowroji Hill collected by Mr. J. Ribiero, a tiny, perfect crystal of apophyllite is seen poised on two needles of okenite. Probably conditions did not present an irreversible sequence. With minerals so similar in composition a slight change in temperature, in pressure, in concentration of any of the components of the system, might alter the necessary conditions for deposition of one mineral to those for re-solution of that and crystallization of the other, while a subsequent change allowed formation of the second without mutilation of the first or even, at a transition point, of simultaneous crystallization of both. Possibly the presence or absence of fluorine was one of the controlling factors. A careful search for fluorine on 2 g. of okenite by the amended method of Berzelius,[3] showed its absence. 0·02 per cent. was found by the method of F. Pisani,[4] but this not qualitatively confirmed. In apophyllite from the same specimen 0·94 per cent. of fluorine was found by the Berzelius method.

Laumontite appears to be the earliest of the three zeolites being found between trap and okenite and sometimes as a nucleus of the okenite spherules.

[1] *Cf.* E. S. Larsen, *Amer. Mineralogist*, VI, 7, (1921).

[2] Prepared at ordinary temperature by the vacuum method of E. A. Wülfing, *Centralbl. Min. Geol. u. Pal.*, 1920, 317.

[3] *Cf.* W. F. Hillebrand, *Bull. U. S. Geol. Surv.*, DCC, 222, (1919).

[4] *C. R. Ac. Sci.*, CLXII, 791, (1916).

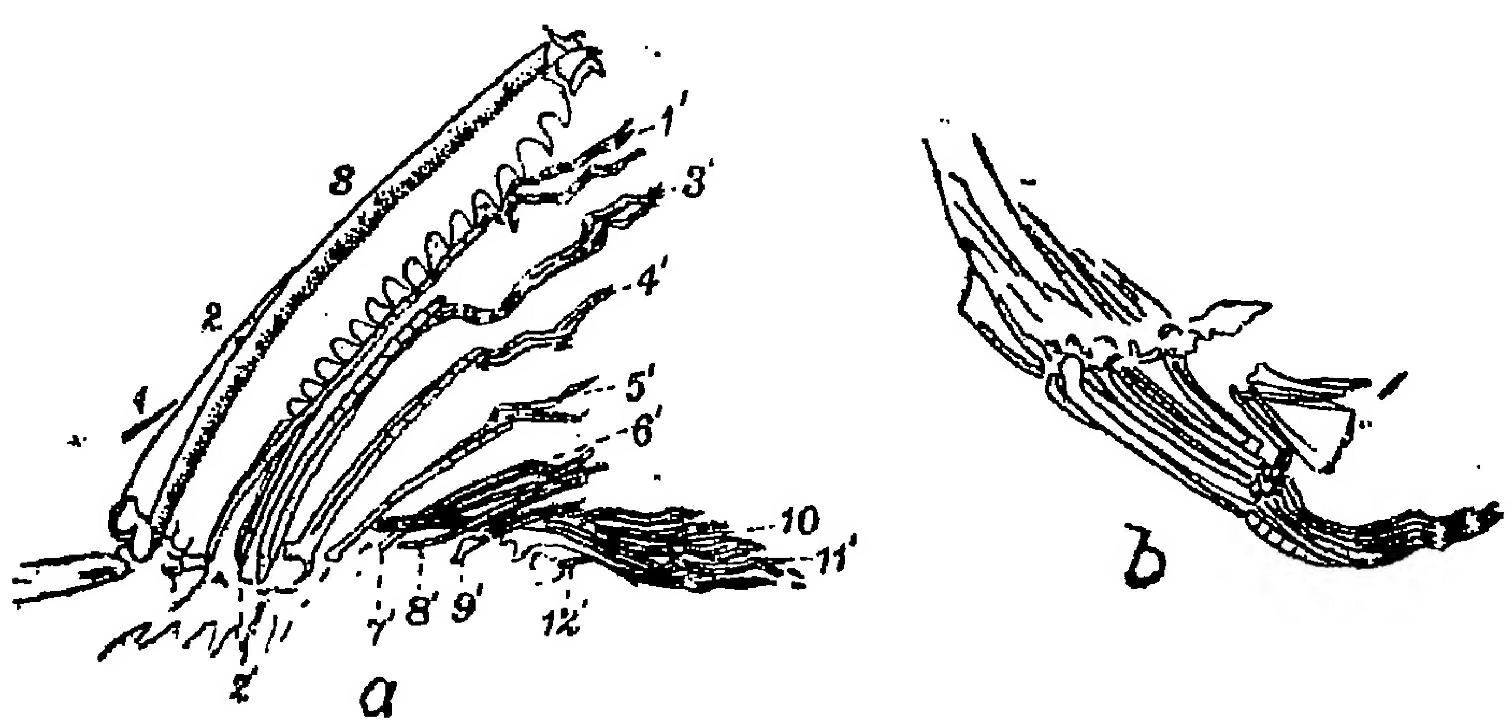
A FRESHWATER FISH FROM THE OIL-MEASURES OF THE DAWNA HILLS. BY THE LATE N. ANNANDALE, C.I.E., D.SC., F.R.S., F.A.S.B., *Director* & SUNDAR LAL HORA, D.SC., *Assistant Superintendent, Zoological Survey of India.* (With Plate 14.)

THE fish described in this note was collected by Professor J. W. Gregory, F.R.S., at Mepale in the Dawna Hills, Tenasserim. Its remains are preserved in stiff clay evidently of lacustrine origin and associated with the limestone in which the shells [1] from the same locality which one of us has recently described were obtained. The type-specimen will be returned to Glasgow University.

The species evidently belongs to the family Cyprinidæ and we believe to the subfamily Cyprininæ, but its characters are so distinct that a new genus must be set up for it. We propose for it the name :—

DAUNICHTHYS, gen. nov.

The head is large and about as deep as the body. It was apparently flattened above with the eyes in its upper half. The jaws are not suctorial. The body is short and moderately deep.



TEXT-FIG. 1.—Dorsal and anal fins.
(*a*) Dorsal fin ;
(*b*) Anal fin.
1, 2, 3 bony spines of the dorsal ; 1'-12' branched and flexible rays of the dorsal.

[1] Annandale, *Rec. Geol. Surv. Ind.*, LV, pp. 97-104, (1922).

There are at least 31 vertebrae, of which 13 appear to be caudal and the caudal and trunk regions are about equal in length. The lateral line runs along the tail below the vertebral column.

The dorsal fin is situated near the middle of the body and is of moderate length. There are at least 15 rays, of which about 12 are branched. The last bony ray is stout and strongly serrated in its upper two-thirds. The caudal fin is long and deeply notched, with the two halves pointed and equal. The ventral lies below the dorsal and has more than six rays, none of which is strongly developed. The anal, which is situated behind the dorsal, is of moderate length and contains two unbranched and 9 branched rays. There is no trace of scales in the specimen.

DAUNICHTHYS GREGORIANUS, sp. nov.

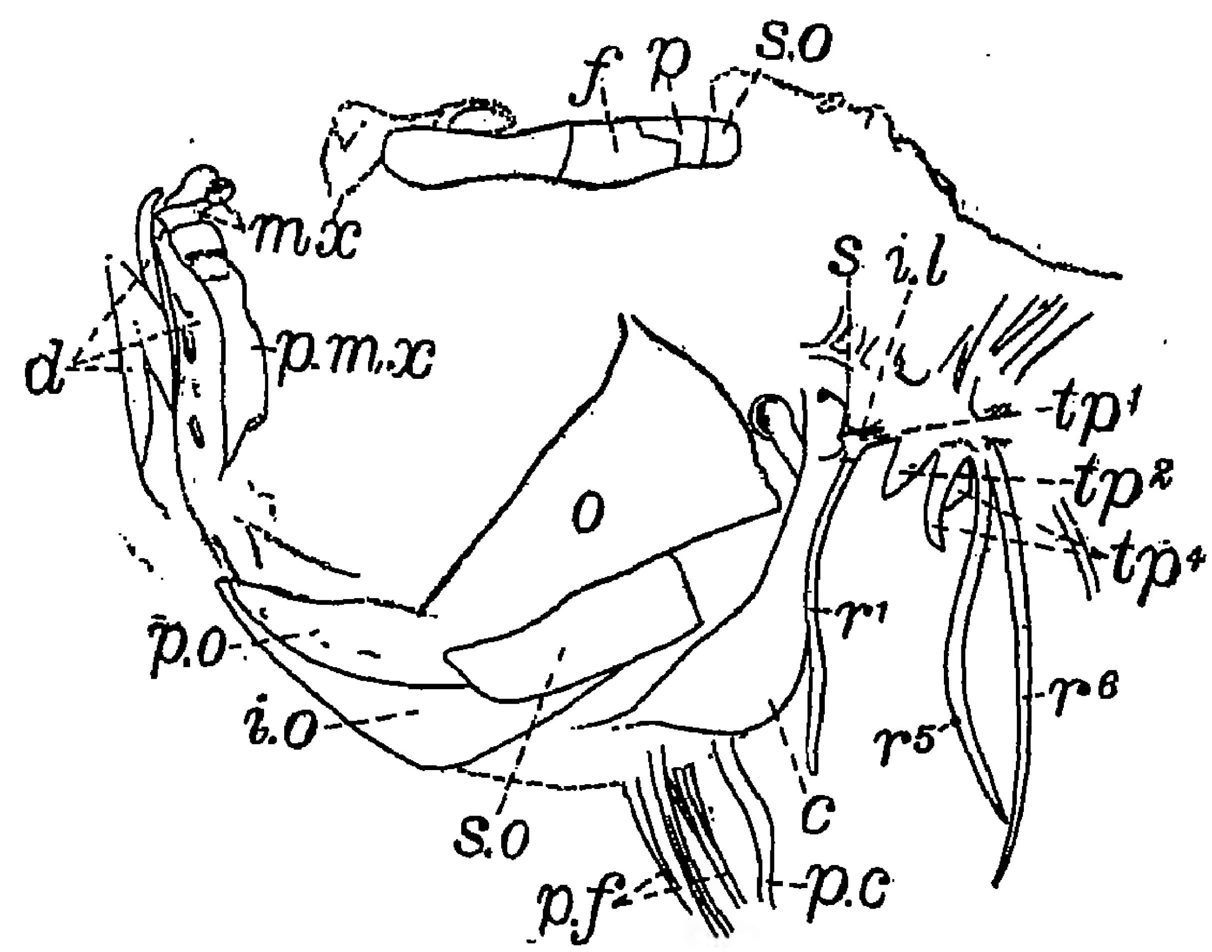
D. 3/12 ; A. 2/9 ; P. 7+; V. 6+; C. 30.

The length of the head is contained 3 times in the total length without the caudal fin. It is as deep as the body. The greatest depth of the body is contained a little over 3 times in the total length without the caudal. The dorsal fin was probably as high as the depth of the body below it. Its first bony ray is short, the second of moderate length and the third much longer and deeply grooved throughout its length. The branched rays of this fin and certain rays of other fins are longitudinally grooved. The pectorals and the ventrals are widely separated and cannot have overlapped. The commencement of the anal is nearer to the ventrals than to the base of the caudal.

The total length of our example is 56 mm., that of the head 14·2 mm., the greatest depth of the body 14 mm., and the length of the caudal fin 13 mm.

Having thus described the genus and the species we will now proceed to examine the specimen in greater detail.

Skull and associated structures:—In the region of the head the jaw-bones, the opercular bones, the secondary pectoral arch and the bones of the brain-case can be distinguished after careful examination, but the other bones have been completely broken up. It seems, however, quite probable that there was a complete circum-orbital ring for traces of it can still be made out. Of the jaw-bones, the lower jaw is broken in the middle longitudinally, while the dentary of the unexposed side, which is also visible, is further broken into two pieces. The maxillaries are represented by nodule-like bones at the top of the premaxillary, which is closely approximated to the dentary. From the direction of the jaws, which are directed



TEXT-FIG. 2.—Bones of the jaws, operculum etc., and the anterior modified vertebrae. *d*=dentary; *mx*=maxilla; *p. mx*=premaxilla; *p. o.*=preoperculum; *i. o.*=interoperculum; *s. o*=suboperculum; *o.*=operculum; *p. f*=pectoral fin; *p. c.*=post clavicular process; *c.*=cleithra; tp^1=transverse process of first vertebra; tp^2=transverse process of second vertebra; tp^4=transverse process of fourth vertebra; r^1=rib of first vertebra; r^5=rib of fifth vertebra; r^6=rib of sixth vertebra; *s*=scaphium; *i. l.*=interossicular ligament; *f*=frontal; *p*=parietal; *s. o*=supraoccipital.

almost vertically upwards in the specimen, it is evident that the mouth-opening must have been directed obliquely upwards as in the living *Catla*. The four opercular bones are quite clear and are well developed. It seems to be quite clear from the position of these bones that they have been detached from the jaw-bones *post mortem* and have been pushed backwards and downwards by external pressure. The secondary pectoral arch is complete and well developed. It is not emarginate anteriorly, but exhibits a somewhat primitive form of the cleithra.[1] The rib-shaped post-clavicular process of the secondary arch is also well marked. Lying alongside the posterior border of the cleithra is a rib-shaped structure, which in all probability represents a rib of the first vertebra, for we know of no other similar structure in this position in the living fishes.

[1] Regan, *Ann. Mag. Nat. Hist.*, (8) VIII, p. 28 (1911).

The brain-case is cracked in several places, but the supraoccipital, the parietal and the frontal can be made out.

Vertebral Column :—In considering the vertebral column of a Cyprinoid fish the chief interest lies in the modification of the anterior vertebrae.[1] This fossil specimen is unique, so far as we are aware, in having a rib of the first vertebra distinct and well developed. The existence of a separate distinct first rib is a very primitive character, but even in living forms the first vertebra possesses a well developed transverse process and in *Catla catla* this is usually an elongated rib-like structure, reaching to about the middle of the transverse process of the second vertebra. The scaphium and a portion of the inter-ossicular ligament of the weberian apparatus are also seen in our specimen slightly above the origin of the rib of the first vertebra. All the trunk vertebrae are covered with skin and muscles and it is difficult to make out their exact structure. Those of the tail region are very clear and are exactly similar to the tail-vertebrae of such fishes as *Labeo rohita*, *Barbus tor* and *Catla catla*. The skeleton of the caudal fin is also similar to that of these species.

Integument.—We can find no trace of scales either detached or *in situ*, but the lateral line is quite clear in the anterior half of the body and can be traced along the caudal peduncle. It lies below the vertebral column and has a slight downward curvature anteriorly, while on the tail it seems to have been nearly straight and to have run parallel to and just below the vertebrae.

Affinities of Daunichthys:—From what has been said above it is abundantly clear that the new genus belongs to the family Cyprinidae and probably to the subfamily Cyprininae. The following combination of characters, however, distinguishes our new genus from all living and fossil genera of the family.

The anal fin is provided with 9 branched rays and does not extend to below the dorsal; the lateral line runs below the vertebral column and in the tail it was probably situated in the lower half of the body; the dorsal fin possesses 12 branched rays and 3 spines, the last spine is deeply grooved longitudinally on the right side and is strongly denticulated posteriorly and the body is entirely scaleless.

In its general facies *Daunichthys gregorianus* resembles certain species of the genus *Barbus* (*s. l.*) and in its up-turned mouth those

[1] Hora, *Journ. As. Soc. Bengal*, (*n. s.*) XVIII, pp. 1-4 (1922).

of *Catla.* Neither *Barbus* nor *Catla,* however, possesses more than six branched rays in the anal fin and both are provided with well developed scales.

A deeply grooved dorsal spine is characteristic of certain living scaleless North American genera of Cyprinoid fishes such as *Meda* and *Plagopterus.* In these this spine is, however, composed of two rays, "the posterior received into a longitudinal groove of the anterior."[1] In the only scaleless Cyprinid fish of the Oriental Region (*Sawbwa resplendens*[2] from the Southern Shan States) the dorsal spine is not grooved and is normal in every respect.

In the following table are given some of the chief characters in which the fossil Cyprinid genera of the Oriental region are distinguished from one another. Of the other fossil genera of the family,[3] some are known from America and others from Europe. Most of these are either described from the remains of the pharyngeal bones and teeth or are characterized by the possession of a long dorsal fin without an osseus spine. In none of these in which the dorsal fins are preserved, are the rays grooved like those of *Daunichthys.*

The Geological Survey of India has recently received from a boring in the Tenasserim coalfield at Kawamapyin, Mergui, certain samples of clay very similar to that in which *Daunichthys* is preserved. They were obtained at a depth of 208 feet. They contain fish spines, which at first sight are very similar to the last bony ray of *Daunichthys,* but closer examination shows that they differ in not being grooved as well as minor characters. It is impossible to assign them to any genus or family with certainty, but they are probably from a dorsal fin of a Cyprinid.

[1] Jordan and Evermann, *Bull. U. S. Nat. Mus.*, XLVII, Part I, p. 328 (1896).

[2] Annandale, *Rec. Ind. Mus.*, XIV, p. 48 (1918).

[3] For an up-to-date list of fossil genera of the family Cyprinidae see names in italics in Jordan's *Classification of Fishes,* pp. 139-144 (Stanford University, California : 1923).

*Thynnichthys.**	*Amblypharyngodon.**	*Barbus* (s. l.).*	*Hexasephus.*†	*Brachyspondylus.*‡	*Daunichthys*, gen. nov.
Dorsal without osseous ray, with 10-12 branched rays.	Dorsal without osseous ray, with 7-8 branched rays.	Dorsal with or without osseous ray, the last osseous ray may or may not be strongly denticulated; with 7-9 branched rays.	....	One osseous ray and 8 branched rays in dorsal.	Dorsal with 3 osseous rays, the last being grooved and strongly denticulated posteriorly; with 12 branched rays.
Anal with 5 branched rays.	Anal with 5, 6 branched rays.	Anal with 5 branched rays.	....	Anal with 10 branched rays.	Anal with about 9 branched rays
Ventrals commencing below dorsal.	Ventrals commencing in advance of dorsal.	Ventrals below root of dorsal.	.....	....	Ventrals slightly behind commencement of dorsal.
Anal entirely behind dorsal.	Dorsal extending nearly to commencement of anal.	Anal behind dorsal.	....	Anal behind dorsal.	Anal behind dorsal.
Scales present.	Scales present.	Scales present.	....	(No indication of scales in the figure.)	No scales.
Pharyngeal teeth with a flat, oblong crown; 5 or 4, 4 or 3, 3 or 2-2 or 3, 3 or 4, 4 or 5.	Pharyngeal teeth molariform with flats or concave crown; 3, 2, 1-1, 2, 3.	Pharyngeal teeth uncinate or spoon-shaped; 5, 3, 2-2, 3, 5.	Pharyngeal bone with 3 large mammaliform teeth arranged in a single series.		

* We have followed Day's *Fishes of India* in our definitions of these genera, which still persist, but *Barbus* is broken up by some (not by all) recent ichthyologists into a number of smaller genera (see Weber and Beaufort's *Fishes of the Indo-Australian Archipelago* III, pp. 89-238 (1916).

† Marck, *Palæontographica*, XXII, p. 411, pl. xxiii, fig. 2; pl. xxiv, fig. 2 (1876).

‡ Günther, *Geol. Magazine* (n. s.) III, p. 439, pl. xvi, figs. 2, 3a, 3b, 3c (1876).

ON A FOSSIL AMPULLARIID FROM POONCH, KASHMIR.

BY B. PRASHAD, D.SC., *Officiating Superintendent, Zoological Survey of India.* (With Plate 15.)

SOME opercula of a Gastropod mollusc recently sent me by Mr. D. N. Wadia, Assistant Superintendent, Geological Survey of India, consist of beautifully preserved and cleaned specimens of an extinct species of apple-snails of the genus *Pachylabra* Swainson. The occurrence of a species of this genus so far north in India is of great interest.

The genus *Pachylabra* [1] is, at the present day, represented by a number of species all over Peninsular India with the exception of Hyderabad, in Assam, Burma and the greater part of the Gangetic Plain. In the Gangetic Plain the range of distribution is limited by a line uniting Lucknow to Aligarh and then running south-west through Bharatpur and Ajmer in Central India to midway between Bombay and Ahmedabad in the Bombay Presidency. In spite of careful collecting at different times, I have failed to find specimens anywhere round Delhi, above Lucknow in the United Provinces, or in the Punjab and Kashmir. The fossil opercula brought back by Mr. Wadia from the Kashmir territory point to a greatly extended range of distribution of the family in former times. This is substantiated by the subfossil specimens of the opercula of an Ampullariid discovered in the Salt Range of the Punjab some years ago by the late E. Vredenburg. Unfortunately none of these specimens is now available for comparison and description.

The fossil opercula from Poonch, Kashmir, represent an undescribed species for which I propose the name *Pachylabra prisca*. The operculum of *P. polita* (Deshayes)—a species from Tonkin, Cambodia and Indo-China—was described by Houssay [2] in detail and the operculum of *P. prisca* resembles it in essentials, but differs in certain well-marked characters. It is also different from that of the common Indian species *P. globosa* (Swainson), which I figure here for comparison.

[1] See Preston, *Fauna Brit. India Freshw. Mollusca*, pp. 96-103 (1915), and Kobelt, Martini and Chemn. *Conch. Cab.* (ed. Küster and Kobelt) *Ampullariidae*, pp. 71-105, (1912-13).

[2] *Arch. Zool. Exper. Gen.* (II ser.) II, p. 232, pl. xi, figs. 4, 10, 11 (1884).

The operculum of *P. prisca* is a concentric, patelliform, calcareous plate of somewhat pyriform shape. The nucleus, which is only to be made out on the external surface, lies near the middle of the plate, quite close to the inner margin, and is surrounded by 7 to 8 rings of growth, which may correspond to the age of the individual. Internal to the nuclear area is the narrow nearly straight region, which, as has been shown by Houssay, is secreted by the posterior part of the foot and consists of vertical plates lying one over the other. Externally this region in *P. prisca* is much narrower than the corresponding one in *P. globosa*. The area external to the nuclear region is secreted by the anterior part of the foot of the animal and is laid in horizontal layers; it is this region which increases in size with the age of the animal and shows the regions of growth. Internally the nuclear region is not distinguishable and its place is taken up by an ovoidal area for the attachment of the opercular muscle. The muscle is mainly attached to a depressed narrow area along the margin and in the centre there is a smooth raised region. In *P. prisca* as compared with *P. globosa* the ring of attachment is more excavated and extensive, while the central smooth region is more raised and convex. The opercula of *P. prisca,* compared with those of *P. globosa,* as seen in photographs of the side views of both species reproduced in Plate 15, figs. 2*b*, 3*b*, are very much thicker and consist of many layers. This appears to indicate that they belong to a species which lived in areas liable either to desiccation and a long dry season or to a long cold winter, in which it was necessary for the preservation of the species to close the mouth of the shell tightly.

Type-specimens:—In the collections of the Geological Survey of India.

According to Mr. Wadia, the thick calcareous opercula were found *in situ* in soft, grey, micaceous sandstone interbedded with bright brick-red clay-shales similar to those characteristic of the Lower Siwalik (Chinji) series, about 1½ miles south-west of Palandri, in the bed of the stream below Phalian village and some 200 yards north of the junction of the Palandri stream. The exact horizon of these beds is in course of investigation by Dr. Pilgrim.

The Gastropod remains were associated with relics of a rather varied vertebrate fauna found in the same vicinity within a few yards, including :—

Cheironeryx silistoensis,—molar and pre-molar.

Rhinoceros mandibular ramus with 1 premolar and 2 molars.

,, incisor fragments.

Chelonia—large number of scutes and plates of the carapace and skull-bones.

Crocodilia—bones and limb-bones.

Snake—vertebrae.

Fish—vertebrae.

Ampullariid—opercular.

EXPLANATION OF PLATE 15.

FIGS. 1, 1a.—Outer, and inner views of the operculum of the type-specimen of *P. prisca*, sp. nov.

FIGS. 2, 2a, 2b.—Outer, inner and lateral views of another operculum of the same species.

FIGS. 3, 3a, 3b.—Outer, inner and lateral views of the operculum of a specimen of *P. globosa* (Swainson) from Calcutta.

All the figures are direct photographs of the opercula and with the exception of 2b are of the natural size of the specimens, Fig. 2b is enlarged twice natural size.

ON A CALCAREOUS ALGA BELONGING TO THE *Triploporelleæ* (*Dasycladaceæ*) FROM THE TERTIARY OF INDIA. BY JOHN WALTON, M.A., *Lecturer in Botany, Manchester University.* (With Plate 16.)

THE name *Triploporelleæ* was given by Oltmanns [1] to a group of fossil algæ, represented by the single genus *Triploporella*, which he considered to be a subdivision of the family *Dasycladaceæ*. The *Siphonocladiales* (which include the *Dasycladaceæ*) differ principally from the other divisions of the *Chlorophyceæ* (Green Algæ) in being infrequently septate; and when septation occurs it is quite independent of nuclear division, the segments containing several nuclei. Generally in this group the more frequently septation occurs the greater is the number of branches and the complexity of the thallus. In the *Dasycladaceæ* there is a strict symmetry in the organisation of the thallus. There is a large axial segment, which bears closely placed branches arranged in whorls; these again may bear smaller branches. The thallus in many of the genera is encrusted with calcium carbonate. Among the subdivisions of the *Dasycladaceæ* the *Dasycladeæ* and *Bornetelleæ* are among living types the closest to the *Triploporelleæ* which Oltmanns regards as intermediate to these two groups.

The material on which the following description is based was sent to Prof. Seward by the Director, Geological Survey of India, together with descriptive notes and illustrations by Mr. B. B. Gupta, Sub-Assistant in that Department; it was collected by the late Mr. Vredenburg from the Ranikot Beds in Sind, which are correlated with the lower Eocene of Europe. The material consists of several separate segments of a narrowly ovate shape (Pl. 16, figs. 1, 2, 3, 4). Those that are complete vary from 4-5 mm. in length and have a maximum diameter at the broadest end of 2·5 mm.

In shape the segments resemble those of *Ovulites margaritula* Lamarck sp.,[2] a branching calcareous alga from the Lower and Middle Eocene of France, Hungary, Belgium, and Italy which Munier-Chalmas [3] considered to be generically identical with *Penicillus* (*Coralliodendron*, Kutz.). Whatever the relationships of

[1] Oltmanns, 1904, p. 277.
[2] Lamarck, 1816. (*See* Seward, 1898.)
[3] Munier-Chalmas, 1880.

Ovulites may be, our fossil is certainly not allied to *Penicillus,* one of the *Codiaceæ,* but must be ascribed to the family *Dasycladaceæ* and to its subdivision the *Triploporelleæ,* (Oltmanns).[1] Nevertheless the occurrence at both ends of the segment of depressions suggests a jointed habit such as is found in the recent genera *Penicillus* and *Halimeda* [2] of the *Codiaceæ* and in *Cymopolia* [3] one of the genera of the *Bornetelleæ* (*Dasycladaceæ*). Mr. Gupta pointed out that there are two depressions at the larger end of one of the segments (Pl. 16, fig. 5) and this may be taken as additional evidence of a dichotomous type of branching such as has been described for *Ovulites.* This segmented branching habit is not known to occur in the other two members of the *Triploporelleæ.* In both Steinmann,[4, 5] describes club-shaped plants with no indication of any continued proliferation of the axis. However in *Triploporella Fraasi,* Steinmann,[6] (Upper Cenomanian) a very long segment is figured with slight constrictions. It may be that these constrictions are foreshadowings of the definite jointed structure found in *Cymopolia* and in our Tertiary form, for which the specific name *ranikotensis* is proposed. In longitudinal section each segment is seen to consist of a single siphon, the diameter of which is very nearly one-third the diameter of the segment as represented in the fossil. From this central siphon lateral branches are given off in whorls (Pl. 16, figs. 8, 9). The section shown in fig. 9, which is transverse to the axis of the segment, passes in a median plane through each of the 15 branches. It will be seen (figs. 6, 10, 12) that the members of successive whorls are usually alternate. The primary branches, the lower portions of which are shown in figs. 8, 9 are marked out by the different nature of the calcareous matter of the fossil between the branches of the first order. This calcareous matter may confidently be assumed to represent the secretion of calcium carbonate on the exterior surface of the cell-wall of the axial siphon and its primary branches; the calcium carbonate deposit is white and opaque whereas the carbonate which fills the lumen of the siphon and its first-order branches is fairly transparent. The preservation is not good and it is doubtful whether

[1] Oltmanns, 1904, p. 277.
[2] Oltmanns, 1904, p. 295.
[3] Oltmanns, 1904, p. 276, Fig. 170, 3.
[4] Steinmann, 1880. (*T. Fraasi*).
[5] Steinmann, 1903. (*T. Remesi*).
[6] Steinmann, 1880, Fig. 1, p. 138.

one can distinguish the pores which must have existed between the axial siphon and its laterals. The amount of weathering to which the surface of the segment had been subjected determined the features seen on the surface. In fig. 12 the pattern on the surface of the two uppermost whorls (*x*) is due to the fact that the weathering has extended for some distance inwards from the outer ends of the branches of the first order which are therefore seen in transverse section (*cf.* fig. 6). In the next three whorls (fig. 12, *y*), three or more darker patches are seen superposed on the end of each first-order branch (*cf.* figs. 2, 3). These represent the lumen of the second-order branches, the lighter network representing the calcareous deposit on the extremity of the first-order branch round the bases of the second-order branches.

Below this zone the hexagonal outlines of the first-order branches are lost to view, and the finer meshed network (*z*) which is seen represents the calcareous deposit between the second-order branches the lumena of which are presented by the slight depressions (*cf.* fig. 1). The organic calcium deposit is apparently more resistant to weathering than the filling material. The number of second-order branches from each first-order branch seems to vary from 2 to 7 in the specimens. In fig. 11 is seen a first-order branch rather shorter than usual, with the basal calcified portions of two second-order branches surmounting it. It has not been possible to distinguish with any certainty the presence of sporangia in this Indian specimen; occasionally, however, there are suggestions that the first-order branches functioned as sporangia, as in *Triploporella Fraasi* and *Remesi*. In fig. 9 there is a gap at (*a*) where three branches have not been preserved. There are also indications of small spherical bodies at the base of one. It is possible that the end portion of the wall of the sporangium was not calcified and hence the sporangium was not preserved. Other examples of the absence of certain members of a whorl of first-order branches of the siphon have been observed (fig. 4, h).

Relationship of the Alga.

In general habit *Triploporella ranikotensis* must have resembled *Coralliodendron* (*Ovulites*) *margaritula* Lamarck sp. and it is to be remarked that they are both of Eocene age. However, on examination of the relation of the lateral branches to the axial siphon in the segments of *Triploporella ranikotensis* it is seen that it is different from any plant described under the name of *Coralliodendron* or

Ovulites and that the forms with which it most closely agrees are those found in the *Dasycladaceæ*. On the whole the shapes of the first-order branches are very like those of *Triploporella*, and the arrangement of the second-order branches is also similar to what is found in that group. Among the large number of forms elegantly illustrated and described by Pia[1] there are a few genera in other groups than the *Triploporelleæ* (Olt.) in which the first-order branches are of this shape; *e.g.*, *Goniolina geometrica* Roem. sp., which Pia groups with *Triploporella* in the *Triploporellineæ*, and *Petrascula*.

It must be noticed tooth at in *Cymopolia* (*Bornetelleæ*) the thallus had a jointed structure, so that in this respect we have another point of contact with that group. As regards the structure of the branches of the first-order and the number of the branches of the second-order our species certainly resembles *Triploporella* (*T. Fraasi* and *T. Remesi*) very closely.

It resembles *T. Remesi* Stein. most closely in the number and arrangement of its second-order branches and *T. Fraasi* Stein. as regards the shape of its first-order branches.

The dimensional relationships between the three species, and one variety, of *Triploporella* which have been described are tabulated below :—

TRIPLOPORELLA.

Species.	*T. Remesi*, Stein.	*T. Fraasi*, Stein.	*T. Fraasi*, var. *minor*, Stein.	*T. ranikotensis*, sp. nov.
Geological Age . .	Jurassic .	Cretaceous	Cretaceous	Tertiary.
Outside dimensions of segments				
(*a*) Length . . .	15 mm. .	15 mm. .		3·5—5·0 mm.
(*b*) Diameter . . .	7—8 μ .	4 μ .	1·5—2·5 μ	2—2·5 μ
(*c*) Number of 1st Ordinary branches per whorl.	60—70 .	34—56 .		15—20
(*d*) Thickness of 1st Ordinary branches.	0·3—0·5 mm.	0·3 mm. .	0·20—0·25 mm.	0·35—0·45 mm.
(*e*) Number of 2nd Ordinary branches per 1st order branch.	3—5 .	3 .		3—7

[1] Pia, 1920.

On arranging the species in order of antiquity it appears that there has been simplification of the vegetative portions of the plant, in particular in the number of first-order branches in a whorl. It must, however, be noted that this is what one would have expected if the size of the first-order branches remained the same and there were a reduction in the circumference of the segment. The constancy in size of the first-order branches is an interesting feature. It is suggested that this may be correlated with the fact that in *Triploporella Remesi* and *T. Fraasi*, as we know definitely, the first-order branches functioned as sporangia and as such might be expected to be more conservative as regards shape and size than purely vegetative organs.

DIAGNOSIS.

Triploporella ranikotensis, sp. nov.

Thallus probably articulate, segments ovoid to conical, in transverse section circular. The extremities of the segments are rounded. The broader, upper extremity has a large depression ; the lower extremity a smaller depression. Average length : 5 mm. Diameter of transverse section at broadest part : 2—2·5 mm. The segments consist of a central axial siphon with closely packed whorls of first-order branch-siphons. The diameter of the axial siphon at any particular level is approximately one-third the diameter of the segment at that level. The first-order branches occur in whorls of 15—20 and are roughly cylindrical but are somewhat flattened at the sides by contact with one another. The spaces between these branches are filled with calcium carbonate secreted by the plant. There are depressions on the outside which represent the bases of second-order branches which arose, 3—7 in number, from the end of each first-order branch.

Locality.—Sind, India.

Horizon.—Ranikot Beds. Tertiary. (Eocene of Europe).

In conclusion, I take the opportunity of expressing my thanks to Prof. Seward of Cambridge who kindly entrusted to me the carrying out of this investigation and to Mr. Gupta who supplied very useful notes and photographs some of which have been used in this account.

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EXPLANATION OF PLATE.

Triploporella ranikotensis, sp. nov.

(Photos. 1, 3, 4, 5, 6 and 7 by B. B. Gupta. Photo. 2 and drawings 8, 9, 10, 11, 12 by J. Walton.) The original specimens are with the Geoloigcal Survey of India, Calcutta.

1. Photo. of a segment covered with the small depressions which correspond to the bases of the 2nd order branches. × 8.
2. Photo. of a segment, weathered a little deeper than that in fig. 1, showing the ends of the 1st order branches outlined faintly by lighter ridges seen clearly at (*b*). Above the middle the 2nd order branch depressions are seen in distinct groups (*c*) corresponding to the underlying 1st order branches. × 8.
3. Photo. of a differently shaped segment with much the same type of structure visible as at (*c*), fig. 2. × 8.
4. Photo. of a segment just above the middle; one of the 1st order branches has not been preserved and is represented by a hole (h). Basal depression, (*d*). × 8.
5. Photo. of larger end of a segment with a double apical depression. × 8.

6. Portion of a segment weathered deeper and showing the 1st order branches in section. × 8.
7. Photo of a longitudinal section of a segment median at the top, tangential at the base. × 8.
8. Drawing of a similar but accurately median section. × 16.
9. Drawing of a cross section of a segment in the state of that represented in fig. 6. (*a*) cavity formed by the non-preservation of three 1st order branches (sporangia ?). × 16.
10. Drawing of segment with tangential slice removed. The whorled arrangement of the 1st order branches is evident. × 16.
11. Drawing of a portion of segment sliced longitudinally and radially showing rather shorter 1st order branch with basal portions of two 2nd order branches. × 16.
12. Drawing of terminal portion of segment showing different stages of weathering. The region (*x*) corresponds to the state of weathering in fig. 6, (*y*) to that in fig. 2, and (*z*) to that in fig. 1. × 16.

FROTH FLOTATION OF INDIAN COALS. BY W. RANDALL, M.SC.

INTRODUCTION.

THE cleaning of coal by froth flotation is a development of the processes known to, and extensively used by, the metalliferous mining industry for some years. It has been successfully applied on a large scale in several countries. During the past two years many of the coals of India have been examined and I am now able to give an indication of the possibilities of applying froth flotation to the treatment of Indian coals.

The advisability of cleaning a coal depends upon the resultant balance between the value of the advantages to be gained by cleaning, and the cost of treatment. The fact that Indian coals have not yet been cleaned on a commercial scale is due, therefore, to one or more of the following reasons :—

(*a*) The coals are of sufficiently high grade for the purposes for which they are used.

(*b*) The nature of the coals does not allow of a useful amount of cleaning being done.

(*c*) The coals are cleanable, but the processes available hitherto have been found to be incapable of treating them successfully on a commercial scale.

Regarding (*a*), general interest in froth flotation is evidence that the development of a process for cleaning Indian coals is desirable. For special purposes, particularly those of the metallurgical industries, there is a demand for high class coals. The supplies of these are not unlimited, and unless coals of lower grades can be cleaned the present indiscriminate use of the unknown reserves of high grade coals is a serious matter. In addition to work on this very important aspect of coal-cleaning, attention has also been given to the possibility of improving the quality of what are now regarded as first class coals.

Referring to (*b*), it is widely known that a large proportion of the ash of most Indian coals is inherent or occurs as part of the coal substance. Some of the coals are practically homogeneous and are therefore not cleanable by any physical process.

On the other hand, many of the Indian coals are heterogeneous; and in these cases (*c*), the advisability of cleaning depends on the result of a balance between advantages and costs. The former are determined by the purposes for which the coal is suitable, and by the extent to which it can be cleaned in practice. These factors depend fundamentally on the constitution of the coal.

In testing samples of coal from various sources it has been found that the constitution of a parcel varies with the following factors:—

(*a*) Its origin, *i.e.* the field, district, and seam.
(*b*) Whether it is representative of the whole or only part of the seam.
(*c*) Whether it is "run-of-mine," or a "screen" product.
(*d*) Whether it has been picked or washed.

Hence the history of any sample submitted for tests is very important. Attention has been given only to samples taken by responsible persons. Samples of run-of mine coal have been obtained directly from working faces. Data concerning the sections and the rejection of shale or other bands have been noted. Samples of screen products have been obtained by special tests on tramloads of coal cut as samples from the coal faces.

CONSTITUTION OF INDIAN COALS.

Most of the Indian coals occur in thick seams, and the proportion of shale bands in the seams is usually very small. The shale bands found in the seams are rarely less than 2 inches in thickness and are therefore easily pickable. Hence the proportion of the ash of picked run-of-mine coal due to shale is in most cases negligible. The bulk of the ash is due to the inferior constituents of the coal itself.

M. Stopes [1] in an important paper, has described the constituents of the bituminous coal of Hamstead Colliery, near Birmingham, England. The publication of this paper did much in directing research on coal towards the investigation of its constituents rather

[1] On the Four Visible Ingredients in Banded Bituminous Coal. Studies in the Composition of Coal, No. 1. Dr. Marie Stopes. *Proc. Roy. Soc. Lond.*, Series B, Vol. XC, p. 470.

than towards that of the coal as a whole. The following is an extract from the publication :—

"Essentially the present contribution to the subject consists in the explicit recognition not of mere "dull" and "bright" bands, but of *four* distinctive and visibly differing portions forming the mass of an ordinary bituminous coal ; and the demonstration of the fact that these four portions can be recognised and separated from each other both macroscopically, by hand, and microscopically in thin sections; and that, further, these four portions react so differently to certain simple chemical treatments as to indicate that their chemical molecules should be substantially different from each other. . . .

These four distinguishable ingredients, all of which, in varying quantities, are to be found in most ordinary bituminous coals, I name provisionally as follows :—

(I) Fusain.—The equivalent of "mother of coal," "mineral charcoal" etc., of various authors.

(II) Durain.—The equivalent of "dull" hard coal of various authors, the "Mattkohle" of Germans, etc.

(III) Clarain. } —Together the equivalent of "bright" or glance coal of various authors, the "Glanzkohle" of Germans. Sometimes the "bright" coal of an author seems to be the vitrain only.

(IV) Vitrain. —(Conchoidal fracture, brilliant in appearance.)

. . . .

The appearances of the four ingredients with the naked eye i.e. *their macroscopic appearances.*

Fusain occurs chiefly as patches and wedges, somewhat flattened parallel to the bedding plane, and often with rather square-cut ends. It consists of powdery, readily detachable, somewhat fibrous strands. The orientation of the fibrous structure tends to be lengthways in relation to each wedge, and the various wedges on a bedding plane lie at various angles to each other, so that in any given light some appear dull and some glisten according to the direction the light catches the fibres.

The fusain is readily separated from the rest of the coal (which is all firmer than it in texture) by delicate scraping with a blunt knife, when the short, fibrous strands and small, sharp-pointed, irregular fragments fall freely on to a paper laid so as to catch them.

Where, as may happen, a thick wedge of fusain is contiguous with a true vitrain band, the fusain may appear as though embedded or sunk in the vitrain. . . . The fusain can then be entirely scooped out, leaving exposed on the vitrain the hollow in which it lay, the surface of this vitrain hollow being curved and smooth. The contact surfaces of both clarain and durain with fusain, however, are much less precise, and an impression of the fibres of the fusain is generally left on the harder durain or clarain after all the friable detachable fibres of the fusain have been removed.

Durain occurs generally as bands of very variable thickness, and when seen in a face at right angles to the bedding plane, they appear parallel to it, though, if traced far enough, they generally reveal their ultimately lenticular shape. Wider bands of comparatively pure durain are less common, but bands, 2, 3, or more inches thick are often sharply differentiated from the adjacent streaky bright clarain.

Durain is hard, with a close, firm texture, which appears rather granular even to the naked eye. However straight the break across it, the broken face is never truly smooth, but, if looked at closely, always has a finely lumpy or matte surface. . . . Generally, even in the dullest of durain bands a few (or many) flecks or hair-like streaks of bright coal are to be seen.

The intercalation of narrow bands of durain and clarain tends to increase at the junction of the broad " dull " and the broad " bright " bands, so that there is no large surface of contact between them which is sharp cut and well defined, even the purest clarain and the purest durain tend to have ravelled edges, which interlock. . . .

Clarain occurs generally as bands of very variable thickness, and when seen in a face at right angles to the bedding plane they appear parallel to it. Like durain bands, they are ultimately widely extended lenticular masses. Clarain, even when considerably streaked with durain, has a definite and smooth surface when broken at right angles to the bedding plane, and these faces have a pronounced gloss or shine. This surface lustre is seen to be inherently banded, as well as to have bands of fine durain intercalated between its own bands. . . .

Vitrain occurs as definite rather narrow bands, in some instances straighter and flatter than the other bands of coal, and in some instances more obviously lenticular. True brilliant vitrain bands are often markedly uniform in thickness for considerable distances, and are commonly from about 2 mm. to 3 or 4 mm. up to 6 or 8 mm. thick, but are very seldom much more than 8 to 10 mm. thick. The limiting layer between the vitrain and the contiguous clarain or durain is generally sharply marked and is often clean-cut definite surface. . . . A single brilliant band does not exhibit the fine banding detectable even in the brightest of clarain, but is a coherent and uniform whole, brilliantly glossy, indeed vitreous, in its texture. The compact vitreous band may split up readily in the fingers to small cube-like segments, but more generally they break irregularly when forced, as with a pen-knife point, when the curved irregular faces have well-marked conchoidal fracture. . . . As was mentioned in connection with fusain, the contact—surfaces of vitrain with the other ingredients of coal tend generally to be well defined with a firm, hard and glassy face."

Examination of a Jharia coal shows that it contains the constituents defined by M. Stopes. The proportion of fusain is usually small, and, like that of the English coal, its analysis varies. Approximate ash contents, at various definite specific gravities, of the more important constituents, are as follows :—

Specific Gravity.	Ash per cent.	Constituent.
1·26	1	Vitrain.
1·30	5	Clarain.
1·35	10	Clarain.
1·40	15	Clarain.
1·45	20	Durain.
1·50	25	Durain.
1·60	40	Durain.

The proportions, and differences in physical properties, of the constituents determine the extent to which the coal can be cleaned by a perfect practical process. Tests at various meshes show that to set free the constituent bands of Indian coals it is necessary to crush the coals to about $\frac{1}{20}$ inch.

Since ash percentage and specific gravity rise together, separation by heavy liquid gives a perfect separation suitable for use in a laboratory examination of the constitution of samples. This will be recognised as the well known "float and sink" test, but to avoid any possibility of confusion with froth flotation I prefer to use the term "separation by heavy liquid," or "heavy liquid separation."

CLEANING PROCESSES.

It will be seen from the above remarks that any cleaning process, to be effective, must be capable of separating the constituents of the coal after it has been crushed to about $\frac{1}{20}$ inch. The factors available for utilization are :—

(*a*) Differences in surface properties of the constituents.

(*b*) Differences in specific gravity of the constituents.

(*c*) Differences in any other physical properties of the constituents.

The possibilities of successfully applying the known coal cleaning processes may now be considered.

GRAVITY WASHERS.

The fact that there is no marked difference in specific gravity of the constituents of Indian coals, and the necessity for fine crushing, are reasons sufficient to explain why no gravity washer has been able to treat these coals on a commercial scale.

HEAVY LIQUID SEPARATION.

This gives a perfect separation which is of value in the laboratory examination of samples, but the process is too expensive to allow of its being applied on a large scale.

TRENT PROCESS.

In the Trent process [1] the coal, ground very fine, preferably to —200 mesh, is mixed with water, and a hydrocarbon oil added at the rate of about 33 per cent. of the weight of the coal. The oil and coal form an agglomerate which separates from the water, while the free ash-forming constituents of the coal remain suspended in the water. It is necessary to add enough oil to fill all the voids between the coal particles, thus substantially excluding the water; the agglomerate may, however, contain 10 per cent. of water. The agglomerate is a plastic mass which could not be used as a substitute for hard fuel. It is claimed, however, that the oil can be distilled from the agglomerate, leaving the pure coal behind. The large quantity of oil required, and the expense of recovering this by distillation, are serious handicaps to this process. So far as I am aware, the process cannot be used to separate the vitrain and clarain from the inferior durain.

The conclusion seems justifiable, therefore, that froth flotation is the only one of the known coal-cleaning processes capable of application on a commercial scale to the treatment of Indian coals.

FROTH FLOTATION.

The determining factor in the operation of this process is differences in surface properties. The separation is independent of differences in specific gravity. Particles of coal of all sizes up to about $\frac{1}{8}$ inch can be "floated," and the fact that Indian coals must be crushed to $\frac{1}{20}$ inch to set free their constituent bands does not handicap the efficiency of the process. Hence the possibility of applying froth flotation to the treatment of Indian coals is determined by their constitution, the differences in their surface properties, and financial considerations.

[1] Trent Patents (British) 183,430; 151,236; 159,497

The process, and the operation of a plant, may be briefly described as follows:—

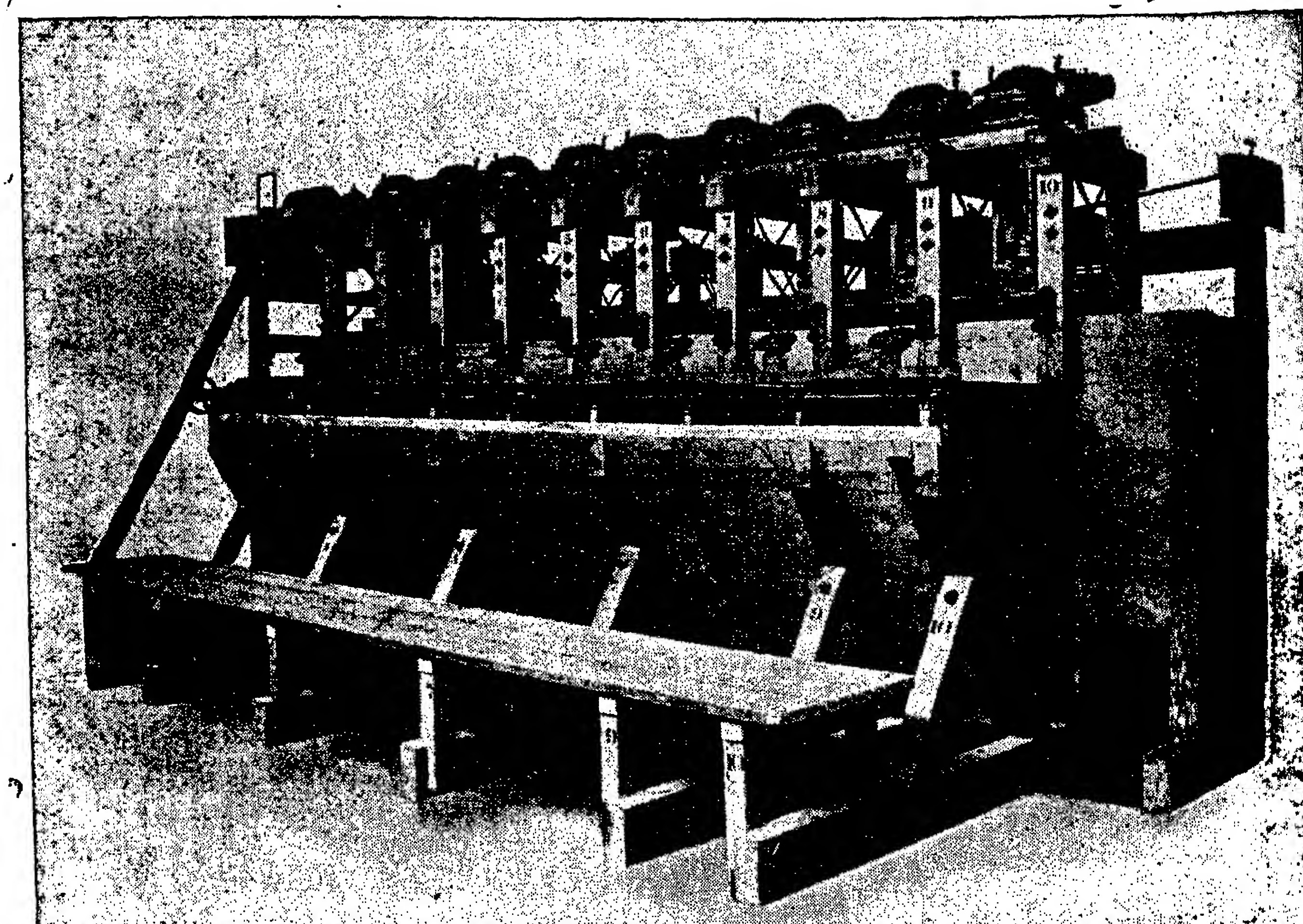

FIG. 1.—GENERAL VIEW OF A FROTH FLOTATION PLANT FOR THE SEPARATION OF COAL.

The coal, along with about four times its weight of water, sufficient to form a mobile pulp, is fed continuously into the first mixing box of the p'ant. By the eddition of a small proportion of a frothing reagent the air entrained by the agitation produced by an impellor forms a multitude of minute air bubbles in the pulp. The pure coal particles, owing to their surface properties, are not wetted by water, and air bubbles become attached to them. The aerated pulp passes through a slot into the first froth box, where, the pulp coming to a state of comparative rest, the air bubbles with their loads of coal particles rise to the surface and form a dense coherent forth which is removed by the paddles. The remainder of the pulp passes from the bottom of the first froth box, through a connecting pipe, to the second mixing box, where it is again agitated and aerated, after which it passes to the second froth box. A commercial scale plant consists of about eight mixing boxes and corresponding eight froth boxes arranged alternately in series. The circulation of the pulp is illustrated diagrammatically in figure 2.

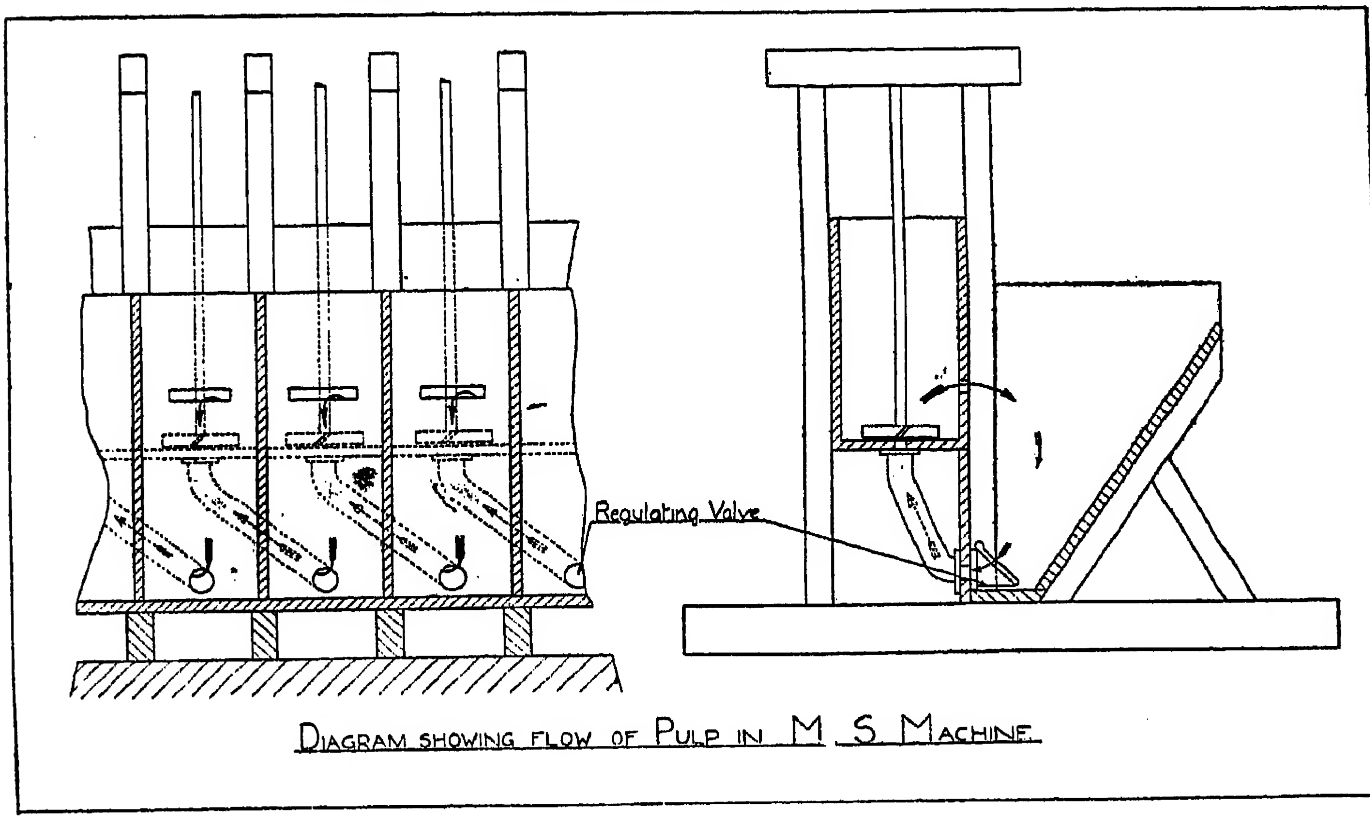

FIG. 2.—SHOWING OPERATING DETAILS OF THE FROTH FLOTATION PLANT FOR THE SEPARATION OF COAL.

The first froth boxes recover the highest grade coal, and the later boxes the poorer grade material. The remainder is discharged from the bottom of the last froth box. Hence, by a suitable arrangement of receiving launders, one or more products may be made as follows :—

1. If the froths from all eight boxes are received by one launder, two products will be made :—
   (*a*) Clean product of high grade.
   (*b*) Remainder of no value.
2. If the froths from the first boxes are received by one launder, and the froths from the later boxes by another launder, three products will be made :—
   (*a*) Clean product of high grade.
   (*b*) Middle product.
   (*c*) Remainder of no value.

The clean coal froth, as removed from the flotation plant, contains about equal weights of coal and water. A method of dewatering this froth has been developed by Messrs. Minerals Separation, Limited, and, as it has been successfully applied on a large scale in England and France, the patentees have kindly supplied the following notes :

" In relation to the dewatering of coal concentrates, the method to be recommended depends on whether it is desirable to make the concentrates into durable briquettes to be subsequently used as fuel, or merely to prepare the concentrates for subsequent coking. In any case, the treatment depends on the fact that, when the coal particles have been superficially coated with a thin layer of tar or the like, their surfaces are no longer wettable by water. As a consequence, the water entangled amongst the particles can be readily pressed out, leaving a product which is relatively free from water.

In the briquetting process, soft pitch in a molten condition, or a molten mixture of tar and hard pitch, is sprayed into the concentrate pulp, which may contain equal weights of coal and water, the pulp being agitated meanwhile. As a consequence the particles become superficially coated with a layer of binder and, on raising the temperature of the pulp to about 60°C-100°C., an intense flocculation is produced. If the flocculated pulp is pressed in a mould provided with means for the water to escape, a hard durable briquette, containing less than 10 per cent. of water, is produced. If the briquette is allowed to stand for a few hours, the content of water drops to 4-5 per cent.

If the coal concentrates are to be dewatered in preparation for subsequent coking, the coating of the coal particles and then flocculation can be effected in cold circuit by the addition of tar, preferably in the form of an emulsion. The flocculated coal can be dried by pressing in moulds or by drainage on a porous belt ; or the water can be pressed out between two porous belts which run between rollers."

For laboratory flotation tests, results of which are given later in this paper, a machine consisting of one mixing box and one froth box, and which is therefore discontinuous in operation, is used. The conditions are essentially similar to those of the commercial plant. Results approximating to those of the perfect separation have been obtained on many Indian coals, and equally good results could, presumably, be obtained in large scale operation.

The possibility of commercially cleaning Indian coals is not limited therefore, as hitherto, by practical difficulties, but by the financial aspect of the matter. The scope of froth flotation is determined, not by its ultimate capabilities, but by the constitution of the coals available for treatment, and by the effects of supply and demand.

CLEANING OF INDIAN COALS FOR COKING.

The nature of the coal, whether coking or non-coking, determines the uses for which it is suitable. The purposes for which the coal can be used determine the advantages to be gained by cleaning. The treatment of coal for coking presents the greatest advantages.

Coking coals are those of which the better constituents are strongly coking, and the inferior constituents are weakly coking or non-coking. In the first-class coking coals the proportions of the constituents are such that the coal gives a satisfactory coke. In the second class coking coals the proportions of the constituents are such that the coal gives a weak coke of high ash content. Some of the more inferior coking coals are of such quality that they may be regarded as commercially non-coking. The difference is merely one of a difference in the proportions of the constituents. Flotation can concentrate the better constituents, vitrain and clarain, and eliminate the higher-ash non-coking ones, durain and fusain. Hence the proportion of clean product, of a quality suitable for coking, which can be separated, depends only on the quality of the seam and its heterogeneous nature, *i.e.* its cleanability. Flotation clean products from second class coking coals have given cokes of excellent quality, and one of the largest iron and steel works in India has expressed the opinion that they are as good as can be desired.

Flotation, or any other process, cannot separate a coking product. from a coal which does not contain any coking constituents India has large reserves of sub-bituminous non-coking coals. Their high moisture contents are an indication of the fact that they are constituted of vegetable products much less altered than is the case in the coking coals. The constituents of these sub-bituminous coals are all non-coking, and for this reason the coals are incapable of being cleaned to yield coking products.

CLEANING OF INDIAN COALS FOR BRIQUETTING.

In general the most inferior constituents of the Indian coals, although of fairly high ash content, have calorific values of 5,000 to 7,000 B. Th. U. For this reason cleaning of the Indian coals cannot appreciably increase their calorific values, and, unless the conditions are exceptionally favourable, cleaning for briquetting will not be profitable.

Results of Flotation Tests.

The better constituents are floated first, and in the later boxes of the plant the froths are of increasingly inferior qualities. Hence the percentage of clean product from any particular coal determines the quality of the product. Results are set out to show this variation, and the quality of the remainder is also indicated. For the sake of simplicity only two products are given, but the question of whether two or three products should be made must be decided in particular cases when the specific requirements can be taken into consideration.

The coals tested may be divided into five classes :

I. Coking coals of Jharia, Bokaro and Barakar.
II. Non-coking coals of the Raniganj district.
III. Coking Tertiary coals of Assam.
IV. Non-coking coals of the Central Provinces, Bihar and Orissa.
V. Non-coking Tertiary coals of the Punjab and the North-West Frontier Province.

Coals which have not yet been tested will probably fall into one of these five classes.

I. Coking coals of Jharia, Bokaro and Barakar.

These are coking coals from Jharia, Giridih, Bokaro, and the Barakar area of the Raniganj field.

Typical analyses are as follows :—

Ash	15	20	25 per cent.
Moisture	1·0	0·8	0·6 „
Volatile Matter	24	23	22 „
Fixed Carbon	60	56	52 „

Jharia.

Results obtained from face samples, representative of run-of mine coal, are set out below :—

Ref. No. 236. "17 Seam," Jharia area. Ash 12·7 per cent.

Clean product .	Weight	60	70	75	80	85	90 per cent.
	Ash .	7·8	8·4	8·8	9·2	9·7	10·2 „
Remainder .	Weight .	40	30	25	20	15	10 per cent.
	Ash .	20·1	22·7	24·4	26·7	29·6	35·2 „

Ref. No. 1067. "15 Seam," Jharia area. Ash 13·6 per cent.

Clean product	Weight .	60	70	75	80	85	90 per cent.
	Ash .	6·6	7·3	7·6	8·0	8·4	9·2 ,,
Remainder	Weight .	40	30	25	20	15	10 per cent.
	Ash .	24·1	28·3	31·6	36·0	43·3	53·2 ,,

Ref. No. 601. "15 Seam," Jharia area. Ash 14·5 per cent.

Clean product	Weight .	60	70	75	80	85 per cent.
	Ash .	9·7	10·4	10·8	11·3	11·6 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	21·7	24·1	26·0	27·3	31·0 ,,

Ref. No. 237. "18 Seam," Jharia area. Ash 16·3 per cent.

Clean product	Weight .	60	70	75	80	85 per cent.
	Ash .	9·4	10·5	11·1	11·6	12·2 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	26·7	29·8	31·8	35·0	39·4 ,,

Ref. No. 438. "14 Seam," Jharia area. Ash 16·6 per cent.

Clean product	Weight .	60	70	75	80	85 per cent
	Ash .	10·1	10·7	11·1	11·5	12·1 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	26·3	30·4	33·1	37·0	42·0 ,,

Ref. No. 437. "12 Seam," Sijua area. Ash 17·0 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	10·8	11·5	11·9	12·4	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	26·3	29·8	32·3	35·4	,,

Ref. No. 646. "16 Seam," Jharia area. Ash 17·9 per cent.

Clean product	Weight	60	70	75	80	per cent.
	Ash .	10·2	11·7	12·6	13·4	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	30·0	32·7	33·8	35·4	,,

Ref. No. 1049. "13 Seam," Jharia area. Ash 18·0 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	10·5	11·5	12·0	12·7	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	29·3	33·2	36·0	39·2	,,

Ref. No. 1068. "14 Seam," Jharia area. Ash 18·2 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	11·6	12·6	13·2	13·8	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	28·1	31·3	33·2	35·8	,,

Ref. No. 604. "11" and "12 Seam," Jharia area. Ash 19·0 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	12·3	13·2	13·7	14·3	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	29·1	32·5	35·0	37·8	,,

Ref. No. 1045. "13 Seam," Sijua area. Ash 19·4 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	12·3	13·3	13·8	14·5	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	30·1	33·6	36·2	39·0	,,

Ref. No. 430. "18 Seam," Sijua area. Ash 19·9 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	13·1	14·5	15·2	15·9	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	30·1	32·5	34·0	35·9	,,

Ref. No. 603. "13 Seam," Jharia area. Ash 20·1 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	11·9	12·8	13·3	13·9	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	32·4	37·1	40·5	45·0	,,

Ref. No. 571. "16 Seam," Sijua area. Ash 21·1 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	14·3	15·6	16·3	17·2	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	31·3	33·9	35·6	36·8	,,

Ref. No. 605. "10 Seam," Jharia area. Ash 21·8 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	16·3	17·3	17·9	18·4	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	30·1	32·3	33·5	35·4	,,

Ref. No. 552. "16 Seam," Jharia area. Ash 22·4 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	11·8	13·7	14·7	15·9	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	38·3	42·8	45·5	48·4	,,

Ref. No. 1950. "14 Seam," Sijua area. Ash 23·4 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	15·5	16·8	17·4	18·0	,,
Remainder .	Weight	40	30	25	20	per cent.
	Ash .	35·3	38·8	41·3	45·0	,,

Ref. No. 1048. "15 Seam," bottom, Sijua area. Ash 28·4 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	20·2	21·9	22·6	23·4	,,
Remainder	Weight .	40	30	25	20	per cent.
	Ash .	40·7	43·6	45·8	48·4	,,

The above results are from face samples, representative of run-of-mine coal, and are arranged in the order of increasing ash-content of the coal. Some seams are more homogeneous, and, therefore, less amenable to cleaning than others. Run-of-mine coal of many seams, of quality up to about 20 per cent. ash, is capable of being cleaned to give a large product of a quality suitable for coking and a correspondingly small remainder of practically no value. Run-of-mine coals of more than 20 per cent. ash, because of their inferior constitution, are generally incapable of giving a large percentage of a product suitable for coking, and in these cases preferential crushing of their better constituents is of great importance.

PREFERENTIAL CRUSHING OF VITRAIN AND CLARAIN.

During mining and subsequent handling, coal breaks along bedding blanes, along cleavage planes, and other directions of fracture. The hetter constituents, vitrain and clarain, are more friable than the parder and inferior durain. Vitrain is also frequently intersected bj joints. For these reasons nearly all the fractures parallel to the bedding planes of the coal are through bands of vitrain. Hence the slack of run-of-mine coal contains a larger percentage of the better constituents than does normal run-of-mine coal from the same seam, and for this reason it is more amenable to cleaning. This is shown by the following results of flotation tests.

Ref. No. 3. "14 Seam," Jharia area. Run-of-mine. Ash 15·6 per cent.

Clean product	Weight .	60	70	80	per cent.
	Ash .	9·8	10·7	11·7	,,
Remainder	Weight .	40	30	20	per cent.
	Ash .	24·3	27·0	31·2	,,

Ref. No. 213. "14 Seam," same colliery as above — ½ inch Slack. Ash 13·1 per cent.

Clean product .	Weight .	60	70	80	90	per cent.
	Ash .	7·4	8·2	9·3	10·7	,,
Remainder .	Weight .	40	30	20	10	per cent.
	Ash .	21·6	24·6	28·3	34·7	,,

Ref. No. 6. "17 Seam," Jharia area. Run-of-mine. Ash 18·5 per cent.

Clean product .	Weight .	60	70	80	per cent.
	Ash .	12·4	13·2	14·0	,,
Remainder .	Weight .	40	30	20	per cent.
	Ash .	27·6	30·9	36·5	,,

Ref. No. 218. "17 Seam," same colliery as above — ½ inch Slack. Ash 16·1 per cent.

Clean product .	Weight .	60	70	80	per cent.
	Ash .	7·5	8·4	10·0	,,
Remainder .	Weight .	40	30	20	per cent.
	Ash .	29·0	34·1	40·0	,,

Ref. No. 821. "16 Seam," Sijua area. Face sample. Ash 18·7 per cent.

Clean product	Weight	60	70	75	80	per cent.
	Ash	10·5	12·1	12·9	13·7	"
Remainder	Weight	40	30	25	20	per cent.
	Ash	31·0	34·1	36·0	38·7	"

Ref. No. 820. "16 Seam," same colliery as above —½ inch Slack. Ash 14·5 per cent.

Clean product	Weight	60	70	75	80	85	per cent.
	Ash	7·0	7·9	8·4	9·0	9·7	"
Remainder	Weight	40	30	25	20	15	per cent.
	Ash	25·8	29·9	32·8	36·5	41·7	"

These tests show that – ½ inch slack, *i.e.*, the portion of the run-of-mine coal which will pass through a screen of ½ inch aperture, is more amenable to cleaning than the aggregate run-of-mine coal from the same seam.

From the above results it will be seen that the practice of using slack for brick burning or as boiler fuel and, frequently at the same colliery, of crushing run-of-mine coal for coking is wrong. Slack should be cleaned for coking.

This preferential crushing of the better constituents can be carried a stage further. The —½ inch slack produced during mining may be about 10 to 15 per cent. of the coal mined. Coals which are not sufficiently amenable to cleaning to be commercially cleanable as run-of-mine coal may be utilized in the following manner. Further preferential crushing may be obtained by breaking the run-of-mine coal to about 1½ inch in a toothed roll type of crusher. The crushed coal, screened on say ½ inch, will give rubble (—1½ inch, + ½ inch) suitable for boiler firing, and "fines" (—½ inch) which may be cleaned for coking. Results obtained in this manner from a tramload of coal cut as a face sample are given below :

Ref. No. 552. "16 Seam," Jharia area. Run-of-mine, unpicked. Ash 22·4 per cent.

Crushed to $-1\frac{1}{2}$ inch, screened on 1 inch aperture screen, this gave the following products :—

			Weight per cent.	Ash per cent.
Rubble, hand-picked	Clean	$-1\frac{1}{2}$ inch, + 1 inch	37·2	21·1
	Reject	$-1\frac{1}{2}$ inch, + 1 inch	5·2	57·8
Fines (Ref. No. 551)		-1 inch	57·6	20·1

Crushed to $-1\frac{1}{2}$ inch, screened on $\frac{1}{2}$ inch aperture screen, the same run-of-mine coal, Ref. No. 552, gave the following products :

			Weight per cent.	Ash per cent.
Rubble, hand-picked	Clean	$-1\frac{1}{2}$ inch + $\frac{1}{2}$ inch	57·3	21·4
	Reject	$-1\frac{1}{2}$ inch + 1 inch	5·2	57·8
Fines (Ref. No. 550)		$-\frac{1}{2}$ inch	37·5	19·2

It will be noted that hand-picking of material smaller than 1 inch has not been attempted, and that the analysis of the material picked out, ash 57·8 per cent., is an indication of the fact that there is sufficient difference in the appearance of the clean rubble and the rejected pieces to allow of picking by unskilled labour.

The word "fines" is used in the special sense of meaning the portion of the crushed run-of-mine coal which will pass through a screen of the aperture indicated. It will be noted on page 236 that a similar product from uncrushed run-of-mine coal is called "slack". Hence, fines is made up of slack *plus* small material produced by mechanical crushing subsequent to mining.

Tests have been done on both 1 inch and $\frac{1}{2}$ inch fines for comparison. The greater cleanability of fines is shown by the following results of tests :—

Ref. No. 552. "16 Seam," Jharia area. Run-of-mine, unpicked. Ash 22·4 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	11·8	13·7	14·7	15·9	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	38·3	42·8	45·5	48·4	,,

Ref. No. 551. —1 inch Fines. See p. 238. Ash 20·1 per cent.

Clean product	Weight .	60	70	75	80	85	per cent.
	Ash .	10·2	11·8	12·7	13·8	14·9	,,
Remainder	Weight .	40	30	25	20	15	per cent.
	Ash .	34·9	39·5	42·3	45·3	49·3	,,

Ref. No. 550. —½ inch Fines. See p. 238. Ash 19·2 per cent.

Clean product	Weight .	60	70	75	80	85	per cent.
	Ash .	9·5	11·0	11·7	12·5	13·2	,,
Remainder	Weight .	40	30	25	20	15	per cent.
	Ash .	33·8	38·4	41·7	46·0	53·2	,,

These results show that a seam, which may not be commercially cleanable as run-of-mine coal, may be crushed to give rubble for boiler-firing or for general purposes, and fines cleanable for coking. The tests done are sufficient to prove the applicability of the suggestion. Further details, such as the amount of crushing to be done and the mesh of the screen to be used for separating the rubble and fines, may be determined by further tests in special cases, when the particular conditions and the financial details of the proposition can be taken into account.

GIRIDIH.

As Giridih is a small field of good quality coal, samples have not been tested.

BOKARO.

Kargali Seam.

The Kargali seam is a coking coal, which is capable of being cleaned as shown by the following results :

Ref. No. 356. Kargali Seam, Face sample. Ash 22·3 per cent.

Clean product	Weight	50	60	70	per cent.
	Ash	14·4	15·8	17·0	,,
Remainder	Weight	50	40	30	per cent.
	Ash	30·2	32·1	34·7	,,

Ref. No. 402. Kargali Seam (same colliery as above) —½ inch Slack. Ash 20·6 per cent.

Clean product	Weight	50	60	70	75	80	85	per cent.
	Ash	9·6	10·5	11·7	12·5	13·2	14·1	,,
Remainder	Weight	50	40	30	25	20	15	per cent.
	Ash	31·6	35·8	41·4	45·0	50·2	57·3	,,

Ref. No. 815. Kargali Seam, Top Section. Face sample. Ash 20·9 per cent.

Clean product	Weight	50	60	70	75	80	per cent.
	Ash	11·0	12·4	14·0	14·8	15·5	,,
Remainder	Weight	50	40	30	25	20	per cent.
	Ash	30·8	33·7	37·0	39·2	42·5	,,

Ref. No. 811. Kargali Seam, Top Section. —½ inch Slack. Ash 17·1 per cent.

Clean product	Weight	50	60	70	75	80	85	per cent.
	Ash	7·7	8·6	9·6	10·3	11·0	11·7	,,
Remainder	Weight	50	40	30	25	20	15	per cent.
	Ash	26·5	29·8	34·6	37·5	41·5	47·0	,,

Ref. No. 817. Kargali Seam, Bottom Section. Face sample. Ash 25·2 per cent.

Clean product	Weight	50	60	70	75	80	per cent.
	Ash	16·5	17·9	19·3	20·0	20·7	,,
Remainder	Weight	50	40	30	25	20	per cent.
	Ash	33·9	36·2	39·0	40·8	43·2	,,

Ref. No. 812. Kargali Seam, Bottom Section. —½ inch Slack. Ash 22·8 per cent.

Clean product	Weight	50	60	70	75	80	per cent.
	Ash	11·2	12·7	14·3	15·1	16·0	,,
Remainder	Weight	50	40	30	25	20	per cent.
	Ash	34·4	38·0	42·6	45·8	50·0	,,

The above results show that slack from the Kargali seam is amenable to cleaning. The clean product from the Kargali coal has been made into coke of excellent quality.

Bermo Seam.

The coal of this seam is very homogeneous. Heavy liquid separation shows that it is incapable of being cleaned.

BARAKAR AREA OF THE RANIGANJ FIELD.

The coals obtained from the neighbourhood of Barakar in the Raniganj field, have a moisture content of less than 1·5 per cent. and are coking. Results of tests on face samples are given below :—

Ref. No. 257. Laikdih Seam. Ash 14·0 per cent.

Clean product	Weight	60	70	75	80	85	per cent.
	Ash	10·4	11·1	11·5	11·8	12·2	,,
Remainder	Weight	40	30	25	20	15	per cent.
	Ash	19·4	20·7	21·5	22·8	24·1	,,

Ref. No. 258. Ramnagar Seam. Ash 13·6 per cent.

Clean product	Weight .	60	70	75	80	85 per cent.
	Ash .	7·6	8·6	9·2	9·8	10·5 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	22·6	25·3	26·8	28·8	31·1 ,,

Ref. No. 260. Ramnagar Seam. Ash 16·7 per cent.

Clean product	Weight .	60	70	75	80 per cent.
	Ash .	10·8	12·0	12·5	13·1 ,,
Remainder .	Weight .	40	30	25	20 per cent.
	Ash .	25·6	27·7	29·3	31·1 ,,

II. Non-coking coals of the Raniganj field.

A typical analysis of coal from the Barakar stage of the Damuda series in the Raniganj field is :—

Ash	17 per cent.
Moisture	4 ,,
Volatile Matter	33 ,,
Fixed Carbon	46 ,,

Very few samples from these beds have been tested. The coals which have been examined are non-coking and are incapable of yielding coking products. On account of the fairly high calorific values of the inferior constituents of the coals, cleaning for general purposes is not likely to be profitable.

III. Coking Tertiary coals of Assam.

The Tertiary coals of Assam are coking. They have very low ash contents, and their chief impurity is sulphur. A typical analysis of the coals is as follows :—

Ash	2 per cent.
Moisture	1 ,,
Volatile Matter	44 ,,
Fixed Carbon	53 ,,
	100

Sulphur . . . . 2 per cent.

The occurrence of the sulphur has been investigated. It is found to be fairly evenly distributed throughout the coal substance. This is shown by the following results of heavy liquid separation :—

Ref. No. 401.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	DIRECT.			CUMULATIVE.		
		Weight, per cent.	Ash, per cent.	Sulphur, per cent.	Weight, per cent.	Ash, per cent.	Sulphur, per cent.
1·230	—	59·6	1·5	1·18	59·6	1·5	1·18
1·235	1·230	22·6	1·5	1·30	82·2	1·5	1·21
—	1·235	17·8	3·2	1·45	100·0	1·8	1·25

The weights of those portions, separated by liquids of various specific gravities, with their analyses, are shown under the heading "Direct." The weights and analyses of those portions obtained in the above direct manner, are successively combined in that part of the table headed "Cumulative."

A better separation than the above is not possible by any physical process. It is concluded therefore that the Assam coal cannot be cleaned. Mixed with Jharia coal the Assam coal gives a satisfactory coke, but the difficulties of mining and the great distance from the iron ore deposits are factors which have to be noted when the Assam coals are being considered as possible reserves of coking coal.

A specimen sample, Ref. No. 313, from another colliery, is even more homogeneous and has the following analysis :—

Ash	1·2 per cent.
Moisture	1·2 ,,
Volatile Matter	44·3 ,,
Fixed Carbon	53·3 ,,
	100·0

Sulphur . . 3·2 per cent.

IV. Non-coking coals of the Central Provinces, and Bihar and Orissa.

Pench valley.

These coals are all of the sub-bituminous, non-coking type. A typical analysis is as follows :—

Ash	19 per cent.
Moisture	6 ,,
Volatile Matter	29 ,,
Fixed Carbon	46 ,,

The coals contain a very small proportion of vitrain and are profusely banded with fusain. Vitrain picked out by hand has the following analysis :—

Ref. No. 359V.

Ash	0·8 per cent.
Moisture	10·9 ,,
Volatile Matter	34·5 ,,
Fixed Carbon	53·8 ,,

In the test for volatile matter the vitrain gives a weakly *fritted*, non-swollen residue. The other constituents of the coal are entirely non-coking. Hence the coal is incapable of being cleaned to yield coking products. The constitution of the coals is shown by the following results of heavy liquid separation :

Ref. No. 359. Face sample. Ash 20·8 per cent. B. Th. U. 10,500.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	Direct.			Cumulative		
		Weight, per cent.	Ash, per cent.	B. Th. U.	Weight, per cent.	Ash, per cent.	B. Th. U.
1·50	—	65·0	12·6	11,700	65·0	12·6	11,700
1·57	1·50	16·4	28·4	9,600	81·4	15·8	11,200
—	1·57	18·6	42·9	7,550	100·0	20·8	10,500

The poorest of the constituents have fairly high calorific values. For this reason cleaning for general purposes is not likely to be profitable. Further, the surface properties of the constituents are such that an unusually large proportion of reagents is required to secure flotation of the better constituents.

Sasti ; Ghugus ; Tulsi, Bisrampur

These coals are all of the sub-bituminous, non-coking type and are considered to be not profitably cleanable.

Talchir.

The seams being worked are of excellent quality. The coal is sub-bituminous and is incapable of being cleaned to yield coking products.

Bhudyar Khad, Daltonganj.

Ref. No. 405.

Ash	19·5	per cent.
Moisture	6·6	,,
Volatile Matter	30·9	,,
Fixed Carbon	43·0	,,

This is a sub-bituminous coal and is entirely non-coking.

It is of interest to note that another sample, Ref. No. 406, from Debi Rai Khad, which is in the same district as Bhudyar Khad, has a remarkably different constitution and indicates that coal of a more highly bituminous nature may be found in this area ; the analysis of this sample is as follows :—

Ref. No. 406.

Ash	13·5	per cent.
Moisture	1·2	,,
Volatile Matter	21·5	,,
Fixed Carbon	63·8	,,

The coal contains a small proportion of vitrain which is strongly coking. It is not commercially cleanable for coking because the proportion of coking constituents is very small.

Karanpura.

This field was not sufficiently developed to allow of representative samples being taken. Examination of specimens from South Karanpura shows that the coal from this portion of the field is sub-bituminous and non-coking.

V. NON-COKING TERTIARY COALS OF THE PUNJAB AND NORTH-WEST FRONTIER PROVINCE.

Maidan Range Coalfield, Punjab.

A typical analysis of coal from this field is given below :—

Ash	6	per cent.
Moisture	4	,,
Volatile Matter	43	,,
Fixed Carbon	47	,,
	100	

Sulphur . . . . 4 per cent.

Results of heavy liquid separation are as follows :—

Ref. No. 645. Face Sample.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	DIRECT.			CUMULATIVE.		
		Weight, per cent.	Ash, per cent.	Sulphur, per cent.	Weight, per cent.	Ash, per cent.	Sulphur, per cent.
1·40	—	88·4	1·9	4·0 (1·40 and 1·50 together)	88·4	1·9	4·0 (1·40 and 1·50 together)
1·50	1·40	6·1	6·0		94·5	2·1	
—	1·50	5·5	34·0	15·0	100·0	4·0	4·6

These figures show that even the better constituents of the coal contain a fairly large proportion of sulphur. Hence no cleaning process can give a product containing appreciably less sulphur than does the run-of-mine coal. The coals are non-coking.

Eastern End of Salt Range, North-West Frontier Province.

Seven samples from this field have the following mean analysis :—

Ash	23·6	per cent.
Moisture	5·0	,,
Volatile Matter	34·6	,,
Fixed Carbon	36·8	,,
	100·0	

Sulphur . . . . 4·8 per cent.

The coals are sub-bituminous and are entirely non-coking. Results of examination by means of heavy liquid separation of a typical sample are set out below:—

Ref. No. 647. Face sample.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	DIRECT.			CUMULATIVE.		
		Weight, per cent.	Ash, per cent.	Sulphur, per cent.	Weight, per cent.	Ash, per cent.	Sulphur, per cent.
1·50	—	69·2	7·6	1·8	69·2	7·6	1·8
1·57	1·50	4·2	25·7	2·8	73·4	8·6	1·9
—	1·57	26·6	58·7	11·8	100·0	21·9	4·5

This result shows that the constitution of the coal allows of a useful amount of cleaning being done. Flotation tests indicate that the coal may be cleanable, but that the consumption of reagents will be exceptionally large because of the nature of the surface properties of this type of sub-bituminous coal. For this reason cleaning may not be profitable and the necessary research has not been undertaken.

The present relative importance of the coals dealt with in this paper can be gauged from Tables 6 and 7 from the Records of the Geological Survey of India, Vol. LV, pp. 174-175, which give the outputs of Gondwana and Tertiary coal in India respectively.

COST OF TREATMENT.

The following estimates of costs have been prepared from data supplied from England suitably amended to suit Indian conditions. The operating charges include power at 0·5 anna per unit, labour, supervision, flotation reagents, renewals, amortization, and royalty to Messrs. Minerals Separation, Limited. The figures are for a large plant designed to treat run-of-mine coal giving a clean product dewatered for coking. For simplicity it has been assumed that the remainder, or tailings, will be worthless, and that all costs are charged to the output of clean product.

Cost of feed. (Rupees per ton.)	Weight per cent of Clean Product.						
	50	60	65	70	75	80	85
	Cost of Clean Product. (Rupees per ton.)						
3 . .	7·6	6·4	6·0	5·6	5·3	4·9	—
4 . .	9·6	8·1	7·5	7·1	6·6	6·2	5·9
5 . .	11·6	9·7	9·1	8·5	8·0	7·5	7·1
6 . .	—	11·4	10·6	9·9	9·3	8·8	8·3
7 . .	—	—	12·1	11·4	10·6	10·0	9·5
8 . .	—	—	—	12·8	12·0	11·3	10·7
9 . .	—	—	—	—	13·3	12·5	11·8

A comparison of the advantages to be gained by cleaning, and the costs of treatment, is now possible. The ash figures given in the results of flotation tests may be replaced by values in rupees per ton and the figures so obtained may be compared with the table of estimated costs given above. It will be seen that if a coal is cheap and/or capable of yielding a large percentage of clean product, treatment may be profitable. Certain of the Indian coals fulfil these conditions. It is hoped to publish further information on the whole question as work developes.

Sampling is of very great importance. Although not given in this paper all data relative to the sections of the seams have been noted.

All the recorded results of analyses are from tests done in the laboratory of the Geological Survey of India by Babu Dulal Chand De. Calorific values given on page 244 are calculated by Goutal's formula from the proximate analyses and are sufficiently accurate for the purpose. Typical analyses are from several samples and are intended to show the differences between the different types of coals.

I wish to express my thanks to Messrs. Minerals Separation, Limited, and to Messrs. Villiers, Limited, their agents in India, for permission to publish this paper; to the several Companies who have given valuable assistance in the field work connected with this investigation; and to Dr. Pascoe, Director of the Geological Survey of India, for his appreciation of the possible importance of this work and his very considerable help in making arrangements for the use of the laboratory in his charge.

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SUBMARINE MUD ERUPTIONS OFF THE ARAKAN COAST, BURMA. BY J. COGGIN BROWN, O.B.E., D.Sc., *Superintendent Geological Survey of India.* (With Plate 17.)

INTRODUCTION.

ON the charts of those parts of the eastern shores of the Bay of Bengal, known as the Arakan coast, the following caution to navigators appears :—

"Mud volcanoes, which occur in the sea, frequently raise islets which may remain above water for some time or quickly sink, leaving dangerous shoals in their places, and a constant and careful look-out is necessary when navigating this coast."

The mud volcanoes of Ramri and Cheduba Islands were first systematically investigated by F. R. Mallet[1] in 1878, and a comprehensive summary of his account has been given by R. D. Oldham in the second edition of the Manual of the Geology of India.

Underlying the shallow waters of the eastern shores of the Bay of Bengal and stretching north and south of the islands already mentioned, there are other localities from which gas, oil and mud are ejected from time to time, sometimes quietly and without any marked disturbance, but, occasionally, with explosive violence, recalling the spasmodic paroxysms of the Cheduba mud volcanoes which distinguish them from others found elsewhere in the oil-bearing regions of Burma.[2]

In the words of Dr. E. H. Pascoe [3],—

"It cannot be too emphatically denied that in Burma the so-called "mud volcanoes" have anything whatever to do with volcanic phenomena. They are entirely due to the escape of gas, the mud and rock fragments being purely accidental accompaniments, and constitute a perfectly normal part of the hydrocarbon occurrences in the 'oil-belts'. There is every gradation between a small insignificant oil or gas seepage and the conspicuous mounds or cones like those on the Arakan Coast, whose terrific outbursts afford some excuse for their having been mistakenly attributed to volcanic disturbance."

[1] F. R. Mallet : "The Mud Volcanoes of Ramri and Cheduba"; *Rec., Geol. Surv. Ind.*, XI, pp. 188-207, (1878).

[2] R. D. Oldham : "A Manual of the Geology of India," pp. 20-22 (1893).

[3] E. H. Pascoe: "The Oil Fields of Burma"; *Mem., Geol. Surv. Ind.*, XI, p. 211, (1912).

The eruptions of the submarine mud volcanoes give rise to the new islands which appear at intervals off the Arakan coast and add to the ordinary perils of these seas.

Apart from the desirability of recording the occurrences for the benefit of navigation, they are of great interest from other points of view, especially for the light they throw on the geology of this part of the Bay of Bengal. To quote Dr. Pascoe again,—

"Their latitude and longitude, for instance, would fix points of probable anticlinal crests. The time of the year at which they occur and even the state of the tide probably have some bearing upon the underground conditions giving rise to the eruptions. Samples of the ejectamenta are of course useful, especially if they should happen to be fossiliferous, since they might be recognisable fragments of known types of rock."[1]

To these suggestions may be added others, such as the vexed question of the means by which the emitted hydrocarbons occasionally become ignited and give rise to fiery eruptions far out at sea, and the connection, if any, which exists between the times of eruption and seismic disturbances elsewhere, for although in their origin they are not associated, contrary to public opinion, with either volcanoes or earthquakes, it has been suggested that the convulsive outbursts are sympathetic responses to seismic disturbances, that an earth-wave may, in fact, act as a hair trigger and detonate the underlying unstable system in which the "mud volcano" is initiated.

In 1885, Mallet published a list of the eruptions which had taken place up to that date.[2] A later one happened on Cheduba Island on 3rd July, 1886.[3] From that time until October, 1893, there are no records of any other disturbances of the group. Accounts of later eruptions have appeared in the Records from time to time until 1912.[4]

[1] E. H. Pascoe, "The Oil Fields of Burma"; *Mem., Geol. Surv. Ind.*, XI, p. 188, (1912).

[2] F. R. Mallet, "On the alleged tendency of the Arakan Mud Volcanoes to burst into Eruptions most frequently during the Rains"; *Rec., Geol. Surv. Ind.*, XVIII, pp. 124-125, (1885).

[3] F. R. Mallet: "Notice of a Fiery Eruption from one of the Mud Volcanoes of Cheduba Island, Arakan;" *Rec., Geol. Surv. Ind.*, XIX, p. 268, (1886).

[4] J. Coggin Brown: "Recent Accounts of the Mud Volcanoes of the Arakan Coast, Burma"; *Rec., Geol. Surv. Ind.*, XXXVII, pp. 264-279, (1908); "Supposed Eruption of a Mud Volcano in the Straits of Cheduba, Arakan Coast, Burma." *Rec., Geol. Surv. Ind.*, XLII, pp. 54-56, (1912); "Eruption of a submarine mud volcano off Sandoway, Arakan Coast, Burma." *Rec., Geol. Surv. Ind*, XLII, p. 278, (1912); "Fiery Eruption of a Mud Volcano on Foul Island, Arakan Coast, Burma." *Rec., Geol. Surv. Ind.*, XLII, p. 279, (1912).

In addition to these an account of a submarine eruption off Ramri Island, which was actually witnessed from the deck of a passing steamer, has been given by Dr. Pascoe.[1]

From 2nd March, 1912, the date on which the mud volcano situated on the submerged reef to the south of Cheduba, known as the Hlaing-bank-kon or as the "Drunken Sailor Rocks," burst into activity, until 1st May, 1914, when an islet appeared above the level of the sea to the south of West Baronga Island, and from that time until the 14th November, 1923, conditions appear to have been quiescent, or, if any eruptions have taken place, they have failed to attract attention, which is unlikely. It now remains to bring these accounts up to date by relating the narratives of observers. They are prefaced by the one which has already been given in part by Dr. Pascoe, but which has not yet appeared in the Records, while the Memoir in which it is reproduced is now out of print.

Submarine Eruption of 30th September, 1908.

On the 8th October, 1909, the Marine Department of the Government of India in Simla issued the Miscellaneous Notification No. 1318-M., being a copy of a telegram from the Secretary to the Government of Burma, to the Secretary to the Government of India, Marine Department, No. 201-C., dated Maymyo, the 6th October, 1909. The notification is given below :—

"Following telegram received from Port Officer, Akyab. *Begins.* Commander, S. S. Katoria, reports witnessed a great volcanic upheaval approximate latitude nineteen dash twenty-one and one-fourth longitude ninety-three dash twenty-two. first upheaval five thirty-five P.M., second five fifty P.M. thirtieth stop each lasting two to three minutes. *Ends.*"

On the 23rd November, 1909, Commander A. R. W. Handcock of the British India Steam Navigation Co.'s R. M. S. Katoria kindly forwarded the following account of these occurrences to the Director, Geological Survey of India :—

"On the afternoon of the 30th September, 1909, whilst on a voyage from Rangoon to Kyaukpyu, I observed a remarkable volcanic upheaval in latitude 19° 21¼′ north and longitude 93° 22′, an account of which may, I think, prove interesting to your Survey Department. The circumstances are as follows :—On the afternoon in question I was steaming up the coast at about 11½ knots an hour on a N. by E. course, weather fine with passing clouds, and a light S. W. wind, when at

[1] E. H. Pascoe : "The Oil Fields of Burma" ; *Mem., Geol. Surv. Ind.*, XL, p. 197.

5-30 P.M. suddenly there was a disturbance right ahead and about 5 miles distant. The disturbance at first resembled the thick black smoke of a steamer on a far off horizon ; this was quickly followed by clouds of steam somewhat resembling a near view of a waterspout in the making ; and about 20 seconds later a great upheaval of water and huge black masses of mud which were so clearly defined at their edges that they resembled great rocks being thrown up in the air, and at first I believed it to be an entire rocky island being thrown up out of the bed of the ocean. This lasted about two minutes, when it rapidly subsided, leaving the water muddy and discoloured round the scene of the upheaval. The height to which the upheaval reached was about 200 feet above the sea, and the length from east to west about 1,500 feet. These measurements are very nearly correct, as there was a steamer nearer the upheaval than I was myself, and as I was able to precisely place the position of the volcanoes, I was therefore in a position to judge dimensions by comparison. At 5-50 P.M. a second upheaval took place also lasting about two minutes, which was similar to the first one and in the same place, though the length from east to west of this, the second eruption, was about 1,000 feet only. The depth of water at the spot is about 13 fathoms. After the upheavals the wind in the vicinity dropped to a calm, though after steaming some 8 miles out to sea, the light S. W. wind set in again.

The clearly defined edges of the black mud as distinct from and not mixed with the surrounding water can, I believe, be accounted for by the fact that petroleum exists in more or less quantities about this part of the Burma coast, and the mud was probably saturated with oil.

The force represented to force up such a large body of mud and water from some 80 feet below the surface of the sea to 200 feet above the surface of the sea must have been very great."

Submarine outbursts of this character and extent have seldom been actually witnessed at the moment before. A search through the old records from 1843 onwards reveals the fact that although flames and their reflections from banks of clouds have been seen, both from the mainland and from the sea, although mud islets of varying sizes, with and without active craters, have been observed, this is the first occasion in which the actual process of a violent eruption at sea has been watched from start to finish. There are several accounts of eye-witnesses of eruptions of the mud volcanoes on land of course.

In one particular, Commander Handcock's narrative recalls that of an earlier observer. In the early hours of 15th December, 1906, a very severe submarine eruption of a mud volcano took place in latitude 19° 0′ 6″ N., and longitude 93° 24′ 20″ E., 8¾ miles in a north-west by north direction from the north-westernmost point of Cheduba Island. Four and a half miles south-east by south from the site lies Beacon Island, and it so happened that Mr. S. Dawson, the Inspector of Light Houses to the Government of Burma, was on this island at the time. He observed the new land at about 7 A.M. in the morning and "about 9 A.M. noted black smoke in two jets like that of a steamer in the distance, and these gradually turned to white steam issuing in one enormous 'cumulus' the whole length of, and above, the island. Later, huge volumes of black mud and water "spouting up into the air to a height of what must have been hundreds of feet" were seen.[1] Commander Handcock's report mentions thick black smoke recalling a steamer on a distant horizon, followed by clouds of steam and then by the eruption of water and black mud. The only material differences in the two occurrences are that the preliminary eruptions, which gave birth to the island on 15th December, 1906, were not witnessed, whereas those of the one under discussion were not large enough to raise an islet above sea-level at all.

Submarine Eruption about 1st May, 1914, off West Baronga Island.

On May 4th, 1914, a notification was issued by the Marine Department in Rangoon, stating that an active mud volcano had appeared in latitude 19° 40′ N. and longitude 93° 02′ 15″ E. Its height on May 1st was about 30 feet and its length about 1 cable, and it showed two summits. Its position was off the long island of West Baronga, near Tiger Point and apparently on the track of vessels between Kyaukpyu and Akyab.

Copies of the notification appeared in the Indian newspapers of May 5th, followed by more detailed accounts on the 6th and 8th of May.

From these it appeared that the island was first sighted from the S. S. "Katoria," a vessel belonging to the British India Steam Navigation Company, Ltd., on May 1st. No active eruption was noticed, but merely an island in a locality where there should have been clear water. In an interview with an "Englishman" representative, which appeared in that newspaper on May 6th, the Commander of the S. S. "Katoria" is reported to have made the following statement :—

"From all appearances it is an island, about a mile in extent and from 25 to 30 feet high. What confirms my conviction that it is an island is its proximity to the island of Baronga, and I should not be at all surprised if it is found to be a part of

[1] J. Coggin Brown : "Recent Accounts of the Mud Volcanoes of the Arakan Coast Burma." *Rec., Geol. Surv. Ind.*, XXXVII, pp. 269-272, (1908).

this island. Another thing that strengthens my belief is the earthquake report issued from Simla last week, for that report stated that the shock came from about a thousand miles distance, and Baronga Island is just about that distance from Simla. Since no other report that would account for the shock has been made it is more than probable that this eruption was the quake recorded on the Simla seismograph."

Later accounts stated that the new mud island, situated about 8 miles south of Baronga Point, was the first to appear in the region for several years, although a number of years previously they were of common occurrence. The R. I. M. S. Mayo passed quite close to the island on the same day as the S. S. "Katoria," and a copy of the report from the Officer commanding the former vessel to the Port Officer, Akyab, is given below :—

"I have the honour to report that a mud volcanic island has appeared to the south of Baronga Point in latitude 19° 40′ N. longitude 93° 2′ 15″ E. Height about 30 feet, length about one cable, in two mounds.

A line of soundings was obtained off the island of 14 fathoms, L. W. O. S., from a position with the island bearing N. 60° E., true distance 2½ miles, to a position with island bearing N. 60° E., true distance 1 mile. Ship's course being N. 30° W. true. The water to the S.-E. of this volcanic island was discoloured for some distance, at least a mile or more. A heavy surf was breaking on the island at the time I was passing, and it was also blowing from the N.-W. (force about 7). I therefore did not lower a boat to make a close inspection.

Suggest that all shipping may be informed at the principal ports."

The island was slowly worn away by the action of the waves and tides and finally disappeared, leaving a dangerous shoal.

Submarine Eruption about November 14th, 1923, off West Baronga Island.

The Indian newspapers of November 16th, 1923, published the following information :—

"The Commander of the steamer 'Chakinda' reports that an island has been formed approximately 1,000 feet long and 20 to 30 feet high, in a position 8·4 miles south and 3 degrees east true from Baronga Point on the spot marked "Mud Volcano 1914."

A reference to the Commander of the S. S. "Chakinda" elicited the reply that he had no further information to add to this telegram.

At a later date the following report on the occurrence was received from Commander A. G. Maundrell, R.I.M., Port Officer, Akyab. It is a copy of one submitted to the Principal Port Officer of Burma.

"The island was examined on November 25th, 1923, and its position fixed as being 8·4 miles, 176 from Baronga Point. The island is composed of black mud, which, being in lumps, gives the idea of rocks, particularly so at the north and south points, where the washing away process has left a few pinnacles. The island is flat-topped, with perpendicular sides and slight ridge running north and south. It is now almost circular, of about 600 feet diameter and 20 feet in height. When fixing its position, the island was circled round at a distance of $\frac{1}{4}$ to $\frac{1}{2}$ of a mile, and no sounding of less than 11 fathoms was obtained. The island was also circled round in a boat at a distance of not more than 200 yards. The island is washing away chiefly from the western side, on which side, at 200 yards distance, soundings of 4 fathoms to 7 fathoms were obtained. On the south side the island is steep to 9 fathoms, close along side on the east side 7 fathoms at 150 yards, and on the north side 7 fathoms at 200 yards. Inside of these distances the water shoals rapidly, and breakers are to be expected. Much discoloured water was passed through when circling the island, and this would appear to be chiefly due to the washing away process, it being noticed that on the flood this discolouration was mostly to the north-east and on the ebb to the westward. It is, I consider, likely that before long the island will disappear, leaving a dangerous shoal, as occurred in 1914.

Owing to the scend of the sea, it was impracticable to land."

The Port Officer adds that the island was first discovered by the Master of the S. S. "Chakinda" on November 14th, 1923, and that so far as he could ascertain, there were no eye-witnesses of the eruption.

The Geological Survey of India is also indebted to Commander Maundrell for a tracing of Admiralty Chart No. 1369 showing the exact position of the island and details of the soundings around it. A comparison of this with the chart itself shows that the new island coincides exactly in position with the one which was formed on May 1st, 1914, and there is no doubt that they were both due to eruptions of mud from the same vent in the floor of the sea.

The prediction that the island would disappear and leave a shoal was proved by the receipt of the following wireless message by the Principal Port Officer, Burma, on the 29th February, 1924, from the Master of the S. S. "Chantala."

"Island reported by Master, Chakdina, in position 8·4 miles S. S. E. true from Bolonga Point has now disappeared and there is nothing showing above water. Breakers mark the position."

EXPLANATION OF PLATE 17.

Map showing position of mud volcano which erupted in May 1914 and November 1923. From Admiralty Chart No. 1369.

NOTES ON CRETACEOUS FOSSILS FROM AFGHANISTAN AND KHORASAN. BY THE LATE H. S. BION, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* WITH AN INTRODUCTION BY J. COGGIN BROWN, O.B.E., D.SC., *Superintendent, Geological Survey of India.*

INTRODUCTION.

(J. C. B.)

AMONGST the papers left by the late Mr. H. S. Bion at the time of his lamented death in June, 1915, were a number of notes on Cretaceous fossils from Afghanistan and neighbouring regions, which it was his intention to bring together into a paper for publication in the Records of the Geological Survey of India. Parts of the notes were typed out and finished, others were in manuscript, while in one or two cases merely the identification of the fossil itself had been made. Before proceeding to give a list of the forms recognised by Mr. Bion, together with such notes on them as he had prepared and his conclusions drawn from a study of the fauna, it is necessary to point out that the bulk of the collection was made by the late Mr. C. L. Griesbach during his deputation with the Afghan Baluch Boundary Commission. To these were added a few forms obtained by the late Sir Henry Hayden during his sojourn in Afghanistan, and one or two more collected by the late Dr. W. T. Blanford from the neighbourhood of Dera Ghazi Khan in the Punjab.

In 1887, Griesbach, as a result of the extensive traverses undertaken in earlier years, was able to demonstrate that rocks of Cretaceous age are widely spread over Afghanistan and Central Asia. They form a large part of Afghan Turkistan, and, to the west and north-west, extend in strips through the Herat province into North-Eastern Khorasan, where apparently all horizons from the Neocomian to the Upper Cretaceous *Exogyra* limestone are represented. Elsewhere, the lower portions of the system are missing. Griesbach found Cretaceous strata in great force between the Hindu Kush and Peshawar, in the south-western prolongations of the Central Afghan ranges, and in the Sulaiman Range. In Khorasan and Northern Persia, Cretaceous rocks form great ranges and play an important part in the structure of the mountain ranges which skirt the northern frontiers of Persia. In Central Asia proper, the Upper Cretaceous covers a large area and hides nearly all the older formations, which appear only in isolated patches where the overlying mantle has been denuded away. To Griesbach, already acquainted with the Central Himalayas and Kashmir, where Cretaceous rocks are comparatively rare, their vast expanses in the regions mentioned were at once arresting and remarkable. His terse descriptions of their prominent features are scattered through a series of papers published between the years 1885 and 1887 under the general title of "Afghan Field Notes." In the first of these, a short report on the geology of the Herat province,[1] there are brief preliminary notices of the Tir-band-i-Turkistan beds. In the second,[2] which deals with the Herat valley in more detail, and in addition with Eastern Khorasan, Griesbach divides the Cretaceous rocks of the latter region into a lower and upper group and traces their distribution generally. The third paper[3] describes reconnaissances carried out between the confines of Afghan-Turkistan and the district of Bamian in Afghanistan, which includes the areas north of the Tir-band-i-Turkistan and the Koh-i-Baba to the Oxus valley. Herein we find the Cretaceous system divided as follows :—

	Formations.	Localities.
Upper	White chalk with flints. *Inoceramus* sp., *Exogyra* sp., many bivalves.	Tir-band-i-Turkistan Range and anticlinals.
	Thick beds of white limestone with *Exogyra* sp.	Main mass of the Kara Koh and folds between Saighan and Tashkurghan.
Lower	Clays, shales, shell limestone, and beds with *Janira quinquecostata*.	Middle course of the Astar-ab and of the Almar Stream.

Detailed descriptions of the various sections are given, together with the following comment on the fauna :—"The commonest fossils found in this group are *Exogyra* sp. and *Janira quinquecostata* besides numerous others which have not been determined yet." Mr. Bion's investigations were concerned mainly with these then

[1] *Rec., Geol. Surv. Ind.*, Vol. XVIII, pp. 57—64 (1885).
[2] *Ibid.*, Vol. XIX, pp. 48—65 (1886).
[3] *Ibid.*, Vol. XIX, pp. 235—267 (1886).

undetermined remains. In the fourth paper,[1] Griesbach considers the geology of the country crossed by the Afghan Boundary Commission on its return to India across the Hindu Kush and through Kabul, while in the fifth[2] and last note, we find his general conclusions accompanying a geological sketch map of Afghanistan and North-Eastern Khorasan, as well as a table in which the Cretaceous rocks of Khorasan, Herat, Turkistan and South-Western Badakhshan are correlated with those displayed in the sections from Sibi to Kandahar and in the vicinity of Kabul.

A quarter of a century later, Sir Henry Hayden's memoir on the "Geology of Northern Afghanistan" was published.[3] Sir Henry in his introduction to this work, wrote :—"What little we know of Afghan geology is due chiefly to Mr. Griesbach's own work in that country between the years 1880 and 1888, the scientific results of which were published in the Records of the Geological Survey of India, Vols. XVIII, XIX, XX and XXV. Since that time nothing has been published on the subject, and the small amount of purely scientific work that I was able to do during a short tour undertaken primarily for the investigation of economic questions has tended to confirm on the whole, and to some extent to amplify, Mr. Griesbach's conclusions."

Describing the Cretaceous system, Sir Henry wrote :—" This comprises by far the most widely distributed group of rocks in Afghanistan to the north of the Koh-i-Baba and the Hindu Kush, From these ranges northwards to the plains of Afghan Turkistan, the whole area was formerly covered by a sheet of Upper Cretaceous limestone, which was deposited unconformably on all older formations." At the base of the series in the neighbourhood of Ishpushta, "there is a well-marked overlap, representing the great Cretaceous transgression which affected such a wide area in Central Asia and which is usually attributed to the Cenomanian period. Although fossils are fairly numerous in the beds above the basal limestone, I was unable to collect more than a very few, and these are all rather badly preserved. In Upper Saighan some shaly marls and arenaceous limestones yielded echinoids and ammonites, which my colleagues, Messrs. E. Vredenburg and G. H. Tipper, have been kind enough to examine for me." Mr. Vredenburg determined the

[1] *Rec., Geol. Surv. Ind.*, Vol. XX, pp. 17—26 (1887).
[2] *Ibid.*, Vol. XX, pp. 93—103.
[3] *Mem., Geol. Surv. Ind.*, Vol. XXXIX, pp. 1—97 (1911).

echinoderms as *Micraster* sp. and *Cyphosoma sp.*, and pointed out that this was the first occurrence of the genus *Micraster* in Asia, and proved that the rocks from which it was derived could not be older than Middle Cretaceous, and probably not older than Cenomanian. Mr. Tipper referred the ammonites to the genus *Hoplites*. "A small fragment of *Scaphites* sp. and a brachiopod very closely allied to, if not identical with *Terebratula semiglobosa* D'Orb., also occur at the same horizon. The limestone overlying these beds is full of lamellibranchs, among which the genus *Exogyra* is very common and led Mr. Griesbach to call the rock, "Exogyra limestone." *Gryphæa vesicularis* Lam. occurs in this limestone at about 150 feet above the horizon of the ammonites and *Pecten* (*Neithea*) *quinquecostata* Sow. The limestones, therefore, are perhaps not older than Senonian, whilst the underlying marls may be as old as Cenomanian."

Such was the state of our knowledge of the Cretaceous faunas of these regions when Mr. Bion commenced his study of the fossils which Mr. Griesbach and Sir Henry Hayden had deposited in the collections of the Geological Survey of India in Calcutta.

Mr. Griesbach's specimens come from various localities in Khorasan and Afghan Turkistan, those collected by Sir Henry Hayden from the Saighan district of Afghanistan, while the few specimens which Dr. Blanford collected are from the Sulaiman Range in the Dera Ghazi Khan district of the Punjab.

List of the Forms identified by Mr. Bion.

Cyphosoma sp.

Micraster præcursor Rowe.

Serpula cf. *gordialis* Schlot.

Serpula filiformis Sow.

Terebratula sella Sow.

Terebratula obesa Sow.

Terebratula biplicata Sow.

Inoceramus balticus Bohm.

Gryphæa vesicularis Lam.

Exogyra decussata Coq.

Exogyra plicifera Duj.

Exogyra ostracina Lam.
Pecten (Neithea) quinquecostata Sow.
Spondylus calcaratus ? Forbes.
Lima obliquestriata Forbes.
Pholadomya cf. *gigantea* Sow.
Cardium sp.

NOTES ON THE FOSSILS.

(H. S. B.)

Cyphosoma sp.

There are two specimens representing this well-known Upper Cretaceous genus, but the preservation is too imperfect to allow of specific identification.

Locality.—K.11-328. Cretaceous marls near the base of limestone cliffs between Begal and Khárgin dara, Saighan, Afghanistan (lat. 35° 11′ : long. 67° 29′).

Micraster præcursor Rowe.

There are six specimens available for description, all more or less damaged. Five of these were collected by Sir Henry Hayden in the Cretaceous marls near the base of the limestone cliffs between Begal and Khárgin dara, Saighan (lat. 35° 11′ : long. 67° 29′). The cliffs alluded to are composed of the Upper Cretaceous *Exogyra* limestones, which are in great part of Campanian age. The exact locality from which the fossils came is marked on the photograph reproduced in Plate 3 of Hayden's memoir.

In the same memoir (p. 36) there is a short note by Mr. Vredenburg to whom the generic identification is due. The note is as follows :—" The four specimens of a spatangoid echinoderm are too crushed and too incomplete for specific determination. Nevertheless the generic characters are perfectly recognisable ; the specimens belong to the genus *Micraster*, the extremely short ambulacral petals recalling forms from the Cretaceous of Europe. So far as I am aware, this is the first Cretaceous *Micraster* obtained in Asia. None, at least, is known from India or Persia. The rocks containing them cannot be older than Middle Cretaceous, probably not older than Cenomanian.[1]

Whilst looking through Mr. Griesbach's earlier collections one more specimen was found belonging to the genus *Micraster*. I have little doubt that it came from the same horizon as the Begal specimens, although it is in an extremely bad state of preservation. The locality given for this specimen is "below *Exogyra* limestone, Middle Cretaceous, Danda Shikan Pass, North of Saighan." The horizon is therefore probably exactly the same. When Mr. Vredenburg's preliminary identification was made the specimens had not been cleaned, and the ambulacra were filled with marl, hence a specific identification was impossible. Since I have cleaned the test, sufficient evidence is available to show that these Micrasters belong to the low zonal forms of the *M. præcursor* group of Rowe.[2]

Measurements.—The three best specimens only have been measured :—

Length	44	44	40 mm.
Breadth	44	41	35 ,,
Height	27	28	22 ,,

These measurements serve to show the only anomalous features of the test, namely, that the breadth is in some fully equal to the length. This is a high zonal characteristic, associated as we shall see with many definite low zonal features. In this connection Rowe remarks—"It appears to be beyond doubt that in each zone there are broad varieties of the narrow forms."

It will be seen that the height is small, the test being depressed as in all low zonal forms. There is no appreciable development of rostrum or carina. The nature of the ambulacra and the inter-poriferous areas agrees very closely with that of forms from the *Holaster planus* zone of the English Chalk. The ambulacra are deep, trough-shaped, and practically smooth. To the naked eye they are certainly quite smooth, and even with the aid of a lens do not show any definite suturing of the inter-poriferous area. The single ambulacrum is a little more advanced as regards suturing and granulation than is the case with the paired ambulacra. It would appear as if the Afghan Micrasters approximate most nearly

[1] Mr. Vredenburg apparently saw only four of the Micrasters from Begal, but there are five in the collection.

[2] A. W. Rowe. "An analysis of the Genus *Micraster*." Q. J. G. S., Vol. LV, pp. 494—547, 1899.

to the passage forms between *M. leskei* and *M. præcursor*. The apical disc is excentric anteriorly. The amount of this excentricity is difficult to measure on crushed specimens, but averages about 4 mm. The mouth is very distant from the border, the measurement being made from the bottom of the notch to the anterior margin of the peristome. The distance so measured is about 9 mm.

The labrum is slight, triangular in shape, widest where it joins the plastron, and from there tapering to a point. The tip of the labrum is smooth, and the labral plate covered only by a few granules. The periplastronal area is only very slightly granulated.

Serpula cf. *gordialis* Schlot.

The only specimen referable to this species consists of round smooth tubes, one millimetre in diameter, irregularly entangled so as to form a nodular mass. There can be no doubt of the identity of this specimen with that figured by Stoliczka from Ariyalur, S. India.

Remarks.—*S. gordialis* is abundant in the uppermost Cretaceous beds of Germany, Northern Austria and France. It seems certain that Stoliczka's view that Sowerby's *S. plexus* from the English Chalk is identical with *S. gordialis*, is correct. The specimen here recorded also comes from the upper beds of the Cretaceous.

Locality.—H. 42/592. Upper Cretaceous limestone, Shadian, South of Balkh.

Serpula filiformis Sow.

Several blocks of limestone in the collection are covered with the long straggling bundles of tubes so characteristic of this species. I have satisfied myself by direct comparison, of the identity of these specimens with those figured by Stoliczka [1] and Kossmat [2] from the Ariyalur beds of Southern India.

Locality.—H. 42/403, H. 42/407. North slope of Zurmust Pass, N.E. of Herat.

H. 42/405. North slope of Band-i-Zurmust, N.E. of Herat.

[1] Stoliczka. "Cretaceous Fauna of S. India." *Pal. Ind.*, Vol. 4, ser. VIII, p. 63, pl. XII, fig. 6.

[2] F. Kossmat. "The Cretaceous Deposits of Pondicherri." *Rec., Geol. Surv. Ind.*, Vol. XXX, pl. 10, fig. 7.

Terebratula sella Sow.

This well-known species is represented by several dozens of specimens from the "Firaiman beds" of Mr. Griesbach.

They were at first regarded as a variety of *T. gregaria* Suess, but subsequently identified by Sir Henry Hayden as *T. sella* Sow., an identification with which I am entirely in agreement.[1]

All the specimens correspond very closely with the true *T. sella* figured by Davidson,[2] rather than with the two other varieties of the species admitted by that author. The specimen from the Isle of Wight which Davidson figured on his Plate VII, fig. 6, fairly represents the Afghan form, there being none with the strongly elevated front shown in fig. 4. The globose variety *T. sella* var. *upwarense* Walker is not represented in the collection.

Locality.—H. 42/279, H. 42/280. 5 miles N.W. of Firaiman, Khorasan.

Remarks.—In England and Western Europe *T. sella* is a typical fossil of the Aptian, and the Afghan examples come from the same horizon.

Terebratula obesa Sow.

There are two specimens referable to this species. One, (H. 42/590) from Shadian, South of Balkh; the other (K. 11/328) from Cretaceous marls near the base of limestone cliffs between Begal and Khárgin dara, Saighan, (lat. 35° 11′ : long. 67° 29′).

The first is a very peculiar form, very wide at the shoulders and tapering to the anterior margin. I have not found any figured form to correspond and refer it with some hesitation to *T. obesa*. The second is a typical *T. obesa*.

Terebratula biplicata Sow.

There are several specimens of this species from the south-eastern slope of Koh-i-ah-i-Shora, south of Shadian, near Balkh, Afghanistan. They are all preserved as casts only (H. 42/543). Others are from Yakh Dara, west of Faughan, south-east of Maimana, Afghanistan (H. 42/574).

[1] Hayden, *op. cit.*, p. 34.
[2] Davidson, "British Fossil Brachiopoda," Vol. 1, plate 7, fig. 6, (1851-55).

Inoceramus balticus. Bohm. 1907.

There are several specimens in the collection belonging to this species, their localities being as follows :—H. 42/466, H. 42/467. Upper Cretaceous, south side of Kelat-i-Nadri, Khorasan. G. 373/2 Lower limestone shales between Mari and Dragal, Kaha Pass, West of Dera Ghazi Khan, (W. T. Blanford).

Mr. Griesbach's specimens are referred to under the name *I. cripsi* Mant. in his paper [1] " Afghan and Persian Field-Notes." It is clear that they come from the Upper Cretaceous beds, so that the present identification as *I. balticus* is in agreement with the stratigraphical position of the fossils. *I. balticus* is characteristic of the Senonian of Europe.

There has been considerable confusion in the use of the specific name *cripsi*, which has been applied wrongly to the Senonian form *I. balticus*. Woods has discussed this question.[2]

Both the specimens from Kelat-i-Nadri and those from the Kaha pass, W. of Dera Ghazi Khan, correspond with *I. balticus* and not with *I. cripsi.* The former is characterised by the much greater length in proportion to the height. The fine specimen of *I. cripsiamis* figured by Stoliczka [3] from the Ariyalur group of South India (which is of Senonian age), is undoubtedly identical with *I. balticus*. Bohm. It is a form intermediate in type between figs. 51 and 53 on pages 294 and 295 respectively of Woods' memoir. It will be seen from the footnote on page 296 that Woods was of the opinion that Stoliczka's specimen was really *I. balticus* and after examination of the type I am quite prepared to endorse this opinion.

Gryphœa vesicularis Lam.

An abundant fossil in the Ariyalur group of South India. It is characteristic of the Campanian beds of Europe and has been found in North America, Algiers, Syria and Asiatic Russia.

Localities.—K. 11/323. Top of the Cretaceous ; 4 miles south-east of Dasht-i-Safed, Afghanistan, (lat. 35° 20′: long. 67° 56′), (H. H. H.).

K. 11/314. End of gorge of Kamard river, left bank, just above Andao, (lat. 35° 30′ : long. 67° 53′), (H. H. H.).

[1] *Rec., Geol. Surv. Ind.*, Vol. XIX, p. 63.

[2] H. Woods. " A Monograph of the Cretaceous Lamellibranchia of England,' Vol. II Pt. VIII, p. 295, (1912).

[3] *Pal. Ind.*, Vol. III, p. 405, pl. XXVII, figs. 1—3, pl. XXVIII, fig. 2.

H. 42/550. Deh Surkh, Astar-ab valley, south of Sar-i-pul, Afghanistan, (C. L. G.).

H. 42/581. Yakh Dara, west of Faighan, south-east of Maimana, Afghanistan.

Exoygra decussata Coq.

This is the most abundant and characteristic fossil of the *Exogyra* limestone of Afghanistan. It occurs in the greatest abundance in certain beds, and as a general rule the larger inferior valve only is preserved. Owing to the strongly arched, gibbous nature of this valve it is impossible to clean out the matter so as to expose the internal characters, and judging by the published figures, very little is known about them.

A comparison of the specimens with those from the European Campanian forming Plate 7 of Coquand's Monograph shows how closely the Afghan forms resemble the European ones.[1]

Localities.—H. 42/527. Bajgah Gorge, between Mathar and Bajgah north of Saighan, Afghan Turkistan.

G. 373/2. Kaha Pass, between Mari and Dragal, Dera Ghazi Khan district, Sulaiman Range.

Remarks.—Among a few specimens brought back by Dr. Blanford from the Sulaiman Hills are some belonging to this species, and which have evidently come from the same set of beds, namely the *Exogyra* limestone of Afghanistan. In Europe *E. decussata* characterises the Campanian. The Afghan specimens and those from the Sulaiman Hills come in all probability, from a similar horizon.

Exogyra plicifera Duj.

The specimens referred to this species are in an excellent state of preservation, and the external and internal characters of both valves are to be seen.

They agree very closely with figures 14, 15, 16, Plate 36 of Coquand, though the Afghan form is more concave posteriorly than the European.

A few remarks are necessary concerning the superior valve. The figure given by Coquand (fig. 18) does not agree with my specimens in that the muscle scar is differently orientated in both. I am at a loss to explain the peculiar position of the muscle in Coquand's

[1] H. Coquand "Monographie du Genre Ostrea," Terrain Crétacé, Atlas, Pl. VII, figs. 1—17 (1 to 69).

figure which is reproduced from that given by Matheron for *E. midas.*

Beyond this feature and the slightly greater concavity in the outline of the valves, there is the closest resemblance between the Afghan forms and the European.

Locality.—H. 42/582. Shadian, South of Balkh, Afghanistan.

Remarks.—*E. plicifera* is stated by Coquand to occur in the Coniacian and Santonian, these divisions representing approximately the lower Senonian of more modern writers. The Afghan specimens appear to come from somewhere in the Upper Cretaceous *Exogyra* limestones.

Exogyra ostracina Lam.

Among the many members of the oyster family from the *Exogyra* limestone I have been able to find only one specimen, and that an isolated lower valve, which may safely be referred to *Exogyra ostracina.* This is rather surprising in view of the wide distribution of this species and its abundance in the South Indian deposits. Whether this rarity is due to the imperfection of the collection under description I am unable to say, but it may be remarked here that the species has not so far been recorded from the Baluchistan Cretaceous.

The length of the valve is 65 mm. and the height 48 mm. The outer or anterior side of the valve is nearly perpendicular, the inner side gently sloping and coated externally with foreign matter to which the animal in life was attached. In consequence of this the external characters of the shell are obscured. It may be observed however, that the beak was strongly and closely incurved, forming more than one complete volution and blending with the valve. The steep anterior side of the shell is rough and irregularly laminated.

The inner side is somewhat prolonged with shelly matter deposited on the object of attachment, but the original outline agreed with the specimens figured by Stoliczka from South India, the posterior margin being nearly straight.

The interior of the valve is well-preserved, and shows a finely crenulated pallial margin.

The muscle scar is a little peculiar, being nearly centrally situated, unusually large and strong, and of somewhat different shape to the published figures of this species. *E. ostracina* is however admittedly an extremely variable species and this variation is most marked both in the shape and position of the muscle scars.

Pecten (Neithea) quinquecostata Sow.

Locality.—H. 52/547. Near Deh Surkh, Astar-ab valley, south of Sar-i-pul, Afghanistan.

Remarks.—This species ranges from the Lower Greensand to the Upper Chalk.

Spondylus calcaratus ? Forbes.

Locality.—K. 11/314. End of gorge of the Kamard River, left bank, just above Andao (lat. 35° 20′ : long. 67° 53′) Afghanistan, (H. H. H.).

H. 42/556. South-eastern slope of Koh-i-ab-i-shora, south of Shadian, near Balkh, Afghanistan.

Remarks.—This species occurs in the Trichinopoly group (Turonian) of South India. As there are no spines or extra prominent primary ribs on the only available specimens, their attribution to *S. calcaratus* is doubtful and it is possible that they may represent *S. truncatus* Gold., though the ribbing is a most variable character.

Lima obliquistriata Forbes.

Locality.—K. 11/314. End of the gorge of the Kamard River, left bank, just above Andao, (lat. 35° 20′ : long. 67° 53′).

Remarks.—This species has been found in the Ariyalur group of South India.

Pholadomya cf. *gigantea* Sow.

This species is represented by one specimen, a cast in which all the shell structure has unfortunately been destroyed.

Measurements.

	mm.
Length	115
Height	58

The dimensions agree very well with those given by Woods and bring out the most characteristic feature of this species, namely its greatly elongated form. The length appears to be always nearly twice the height. The number of ribs and the other characters of the shell, in so far as they are observable, are in agreement with the published descriptions of this species.

Locality.—K. 11/328. Base of limestone cliff, between Begal and Khárgin dara, Saighan.

Remarks.—In England *P. gigantea* occurs in beds of Aptian age; western Europe it is found in the Valenginian Neocomian and ian; in German West Africa, from the base of the Neocomian the top of the Aptian. This Afghan specimen came from the s just below the *Micraster* horizon and would appear therefore occur here at a somewhat higher horizon, possibly the Cenomanian.

Cardium sp.

This cast of a Cardium appears to be allied to *Cardium produc-* Sow., but the specimen is far too badly preserved for specific ermination. As far as observable the characters of this species present. The ribs were numerous and with the lines of wth seem to have divided the shell surface into a serrated series rectangles so typical of the *Cardiidæ.* Traces of tubercles or nes are still to be seen on the front of the valve.

Locality.—K. 11/314. End of gorge in Kamard River, left bank, above Andao, (lat. 35° 20′: long. 67° 53′).

Conclusions.

Mr. Bion summarized his conclusions as follows:—

"The fauna is dominated by lamellibranchs, of which the ræidæ are by far the most abundant group.

The conditions of deposit must have been those of a compara-ely shallow sea, the maximum depth of water being reached during great Upper Cretaceous transgression. It would appear as if ing Upper Cretaceous times, Afghanistan had formed the eastern remity of the South European province. Such a generali-on may seem premature, based as it is on a very small collection fossils, nevertheless the similarity to the European fauna is so rked that the inference is perhaps excusable.

Unquestionably the chief feature of interest lies in the strong ropean affinity of the fauna. Almost without exception the cies met with can be matched in Europe, and in no direction this similarity more strikingly shown than in the occurrence of typical Upper Chalk genera *Cyphosoma* and *Micraster.*

In all, 13 species have been identified ranging, probably, from Vectian[1] to the Campanian."

[1] Vectian is the term adopted by A. J. Jukes-Browne for the Lower Greensand (*Proc. . Assoc.*, Vol. XII, p. 262, 1891-92).

GIPC—M—V-2(1)—14-4-25—800.

CALCUTTA
GOVERNMENT OF INDIA PRESS
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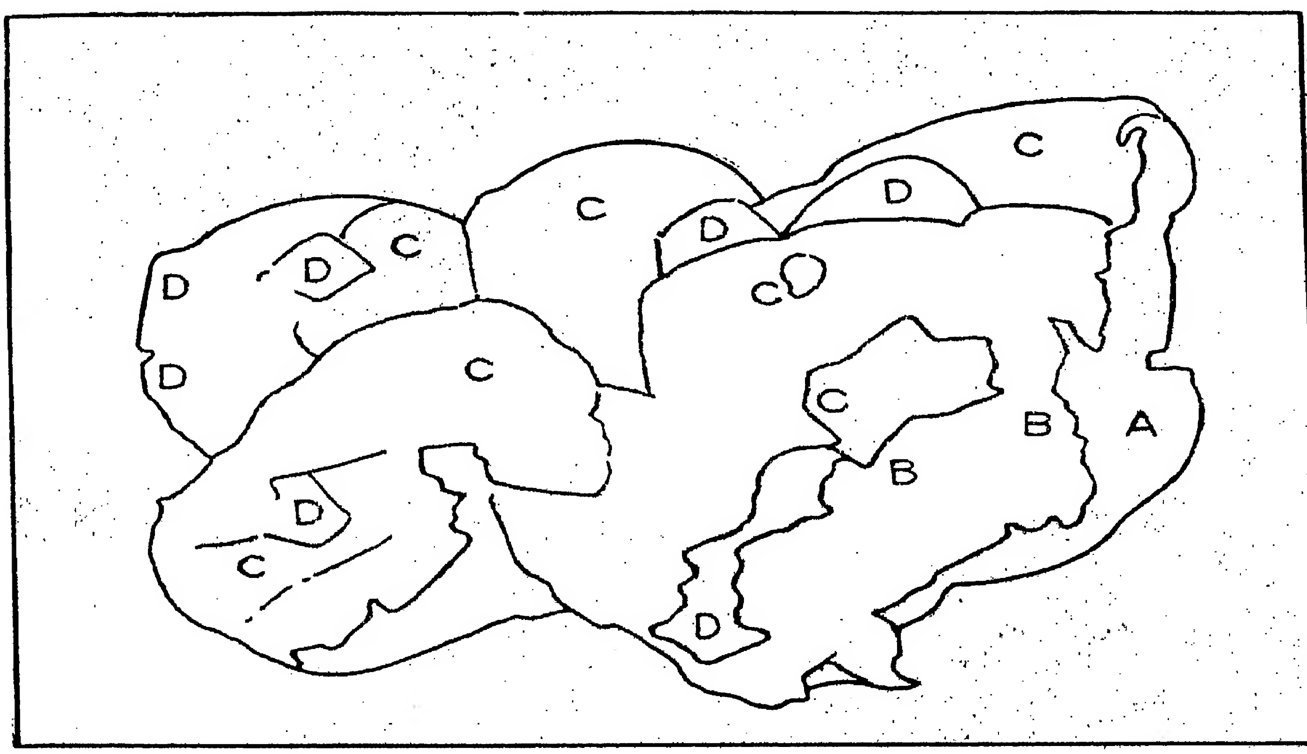


FIG. 2. OKENITE. *(Natural size).*

A = trap ; B = laumontite ; C = okenite ; D = apophyllite.

FIG. 1. GYROLITE ON CALCITE. × 3.

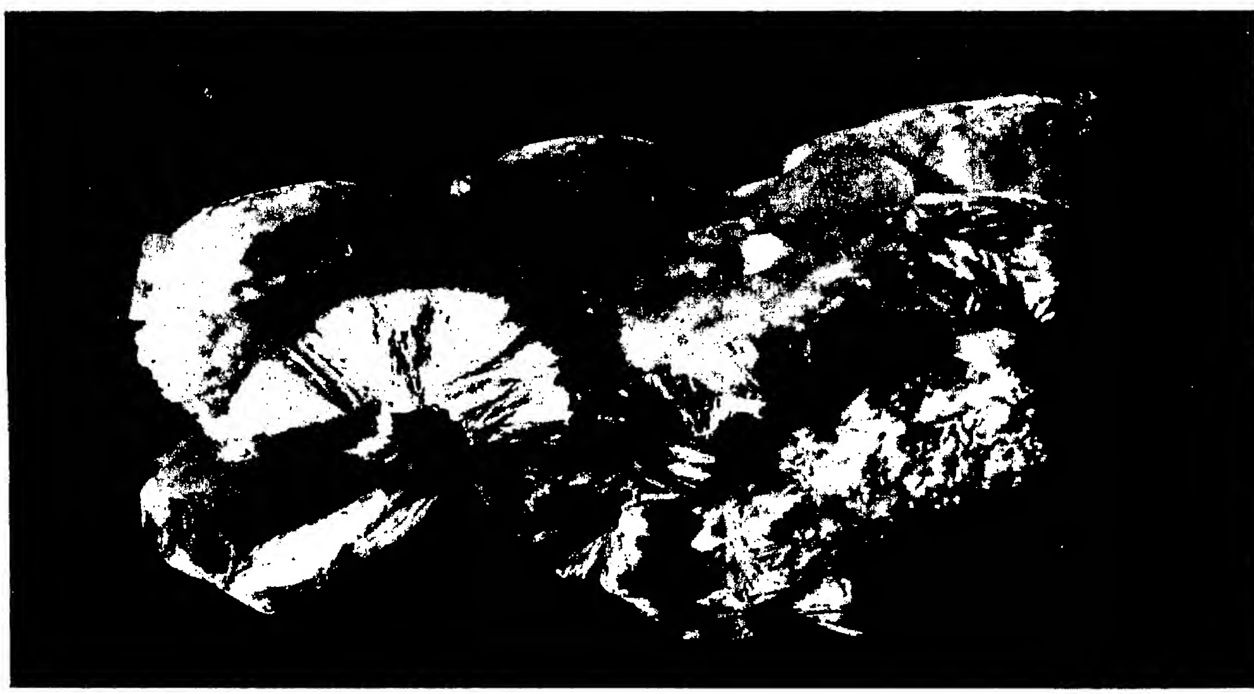


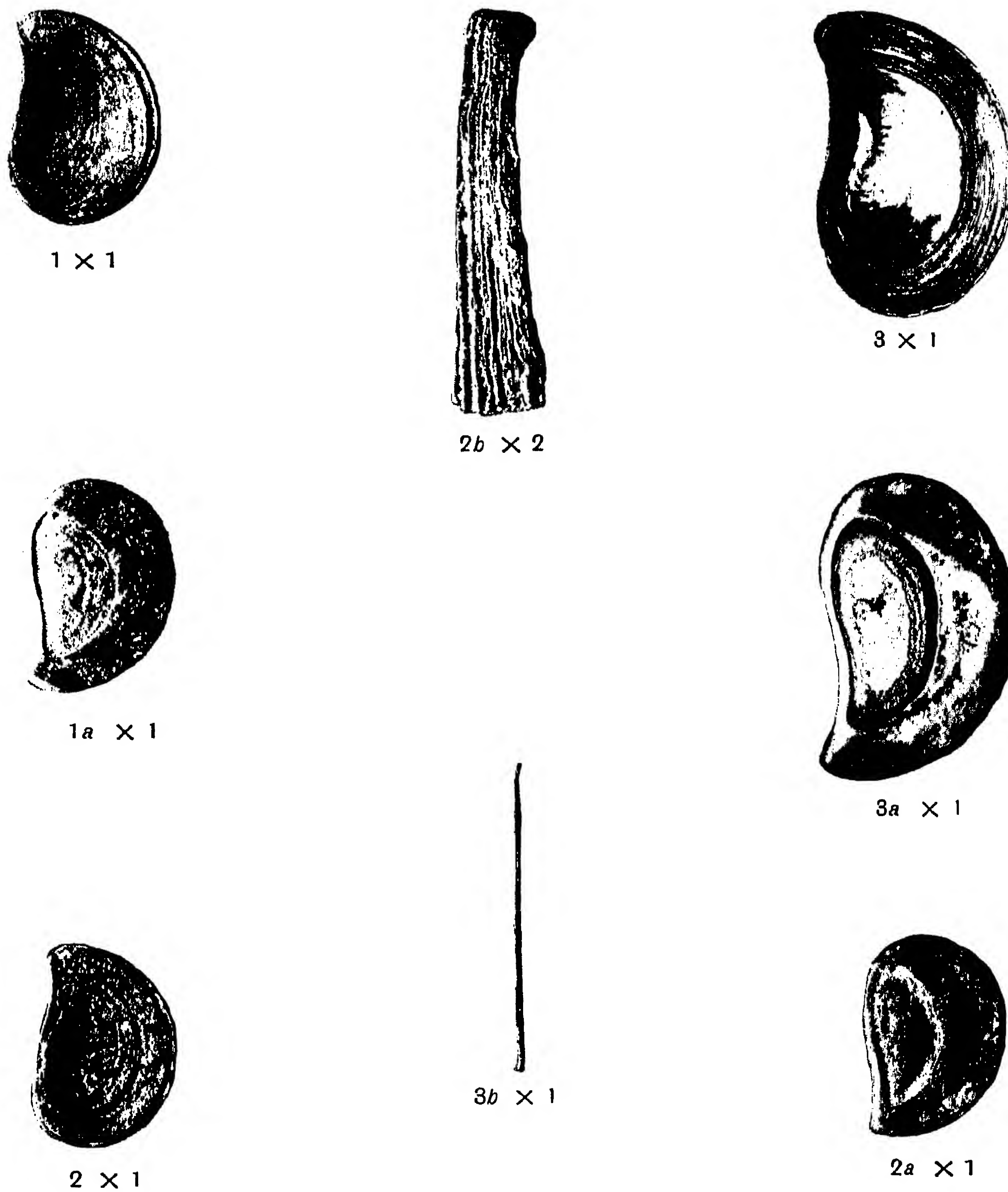
FIG. 2. OKENITE. *(Natural Size).*

K. F. Watkinson, Photos. *G. S. I. Calcutta.*

FIG. 3. OKENITE ON APOPHYLLITE. × 15.

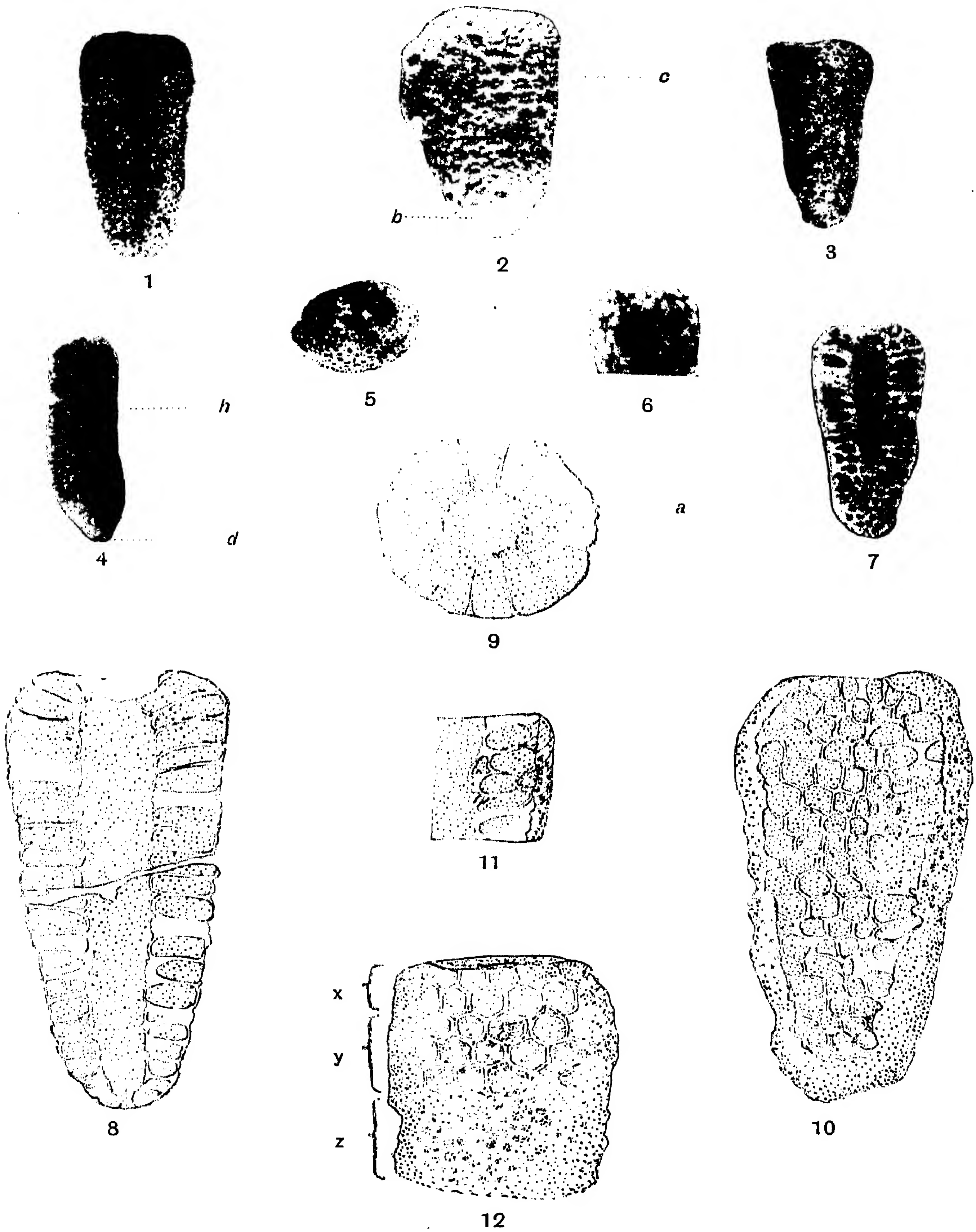
Z. S. I. Photo. G. S. I. Calcutta.

DAUNICHTHYS GREGORIANUS, *SP. NOV.* × 3



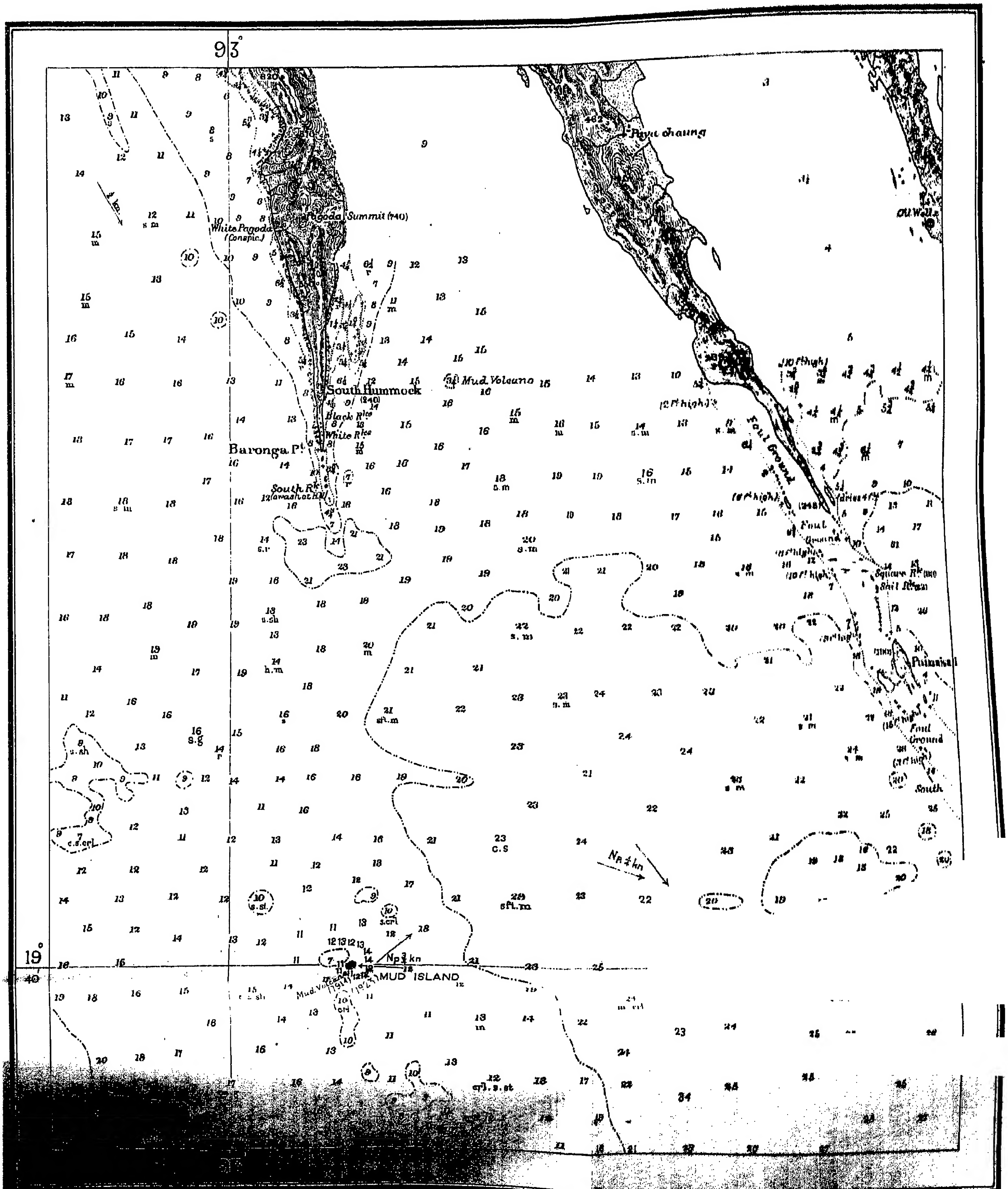
Z. S. I. Photos. *G. S. I. Calcutta.*

FIGS. 1, 1*a*, 2, 2*a*, 2*b*. PACHYLABRA PRISCA, *(SP. NOV.)*
FIGS. 3, 3*a*, 3*b*. PACHYLABRA GLOBOSA.



Drawing Office, Photos. *G. S. I. Calcutta.*

TRIPLOPORELLA RANIKOTENSIS *SP. NOV.*



Litho. G. S. I. Calcutta.

... OF MUD VOLCANO WHICH ERUPTED IN
... 1914 AND NOVEMB...

Scale 1 inch = 2 miles

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4] 1925

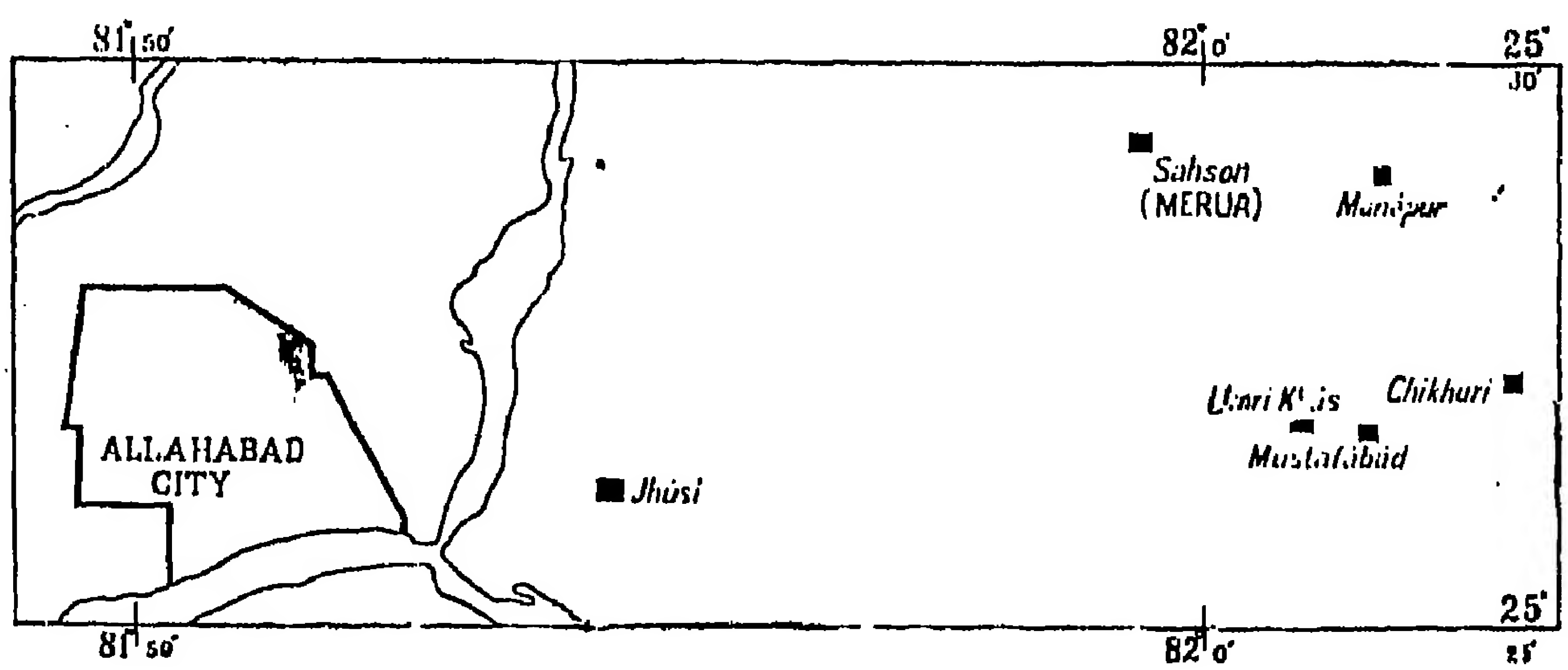
THE MERUA METEORITE. BY G. H. TIPPER, M.A., F.G.S., F.A.S.B., M. INST., M. M., *Superintendent, Geological Survey of India.* (With Plates 18—27).[1]

THIS meteoric shower named after the village where the largest fragment fell, occurred on the 30th of August, 1920, at approximately 11-15 A.M. Mention is made of the fall in the Annual Report of the Geological Survey of India of 1921. (Rec. G. S. I., LIV, p. 10).

Circumstances of the Fall.

The circumstances attending the fall are narrated by Mr. B. Srinivas, Deputy Magistrate, Allahabad, who was deputed to report on the fall.

From the report it appears that in all six pieces fell, the largest at Merua, 2 pieces at Manpur Urf Baghai Kalan, 1 at Chukri, 1 at Umri and 1 at Mustafabad. The location of these villages in relation to Allahabad is shown in the accompanying sketch plan.



[1] The plates illustrating this paper were prepared by one of my colleagues who had hoped to write the description but was prevented by circumstances.

"All these falls took place simultaneously, the exact time of which is not known, as the villagers had only a vague idea of the time of day. Superficial examination will show that they are parts of one mass, and must have fallen at one time."

"The big piece fell down at Merua in a field. It was a cloudy day and hence nobody saw any flash. The stone came in a slanting position from the east, and went down six feet inside the earth obliquely. A small boy named Tahal had seen it coming. There was a sharp thundering report at first, and it was followed by less noisy detonations. The boy told me that on hearing the first sound, somebody told him that it was going to rain, but it kept on rumbling. Then there was a whizzing sound as if something was coming down. The boy says that he thought the cloud itself was coming down, everybody was frightened, and he himself left cutting grass and fled. He says that he saw something like a kite coming down with a great velocity from the eastern portion of the sky. The stone was coming down with a loud whizzing noise, and did not leave any trail behind. Nobody went near it at once as everybody was afraid. After two or three hours the villagers mustered courage to dig out the place."

"It may be mentioned that the first loud noise was clearly heard at Allahabad. I myself heard it and a friend of mine happened to look at his watch at the time as he took it to be the gun from the fort. It was exactly 11-14 A.M., when the noise was heard in Allahabad."

"Two pieces of stone came down in Manpur Urf Baghai Kalan. Only one piece was seen coming down by Nimai. Nobody witnessed the fall of the other piece. It was forty feet high when Nimai saw it coming from the east. It went down 1½ feet inside the earth in a slanting position, and this man went and picked it up soon afterwards. It was a little warm and grew cold soon. At Mustafabad only one piece came down, and nobody saw it in the sky. Ganga, who was 8 or 9 bighas away when the piece fell down, found it to be quite cold when he went there and picked it up. It went a few inches inside the earth."

"One piece came down at Chukri. Datadin saw it coming down from the east and the piece went obliquely a few inches inside the earth. Datadin found it a little warm when he picked it up. The fall of one piece at Umri was not witnessed by anybody. Bhagwati picked it up after some time and found it quite cold."

Five pieces of the fall were received from the Collector of Allahabad. These weighed, respectively, (*a*) 56·689 kilos, (*b*) 9·197 kilos, (*c*) 3·019 kilos, (*d*) 1·544 kilos, and (*e*) ·957 kilos, the total weight of these portions of the fall being 71·406 kilos. Of these (*c*) and (*d*) were sent originally to the Government Laboratories in London, in connection with the research on extra-terrestrial chlorine. These two portions are illustrated on Plate 25, figs. 1, 2, 3. On analysis in which 23 grammes of material were used, no chlorine was found and the remainder was presented to the British Museum, Natural History Section. Portions (*a*), (*b*) and (*e*) remained in the custody of the Geological Survey of India, where they bear the number 279 in the meteorite collection.

The following is a description of the physical appearance of portions A, B and E which are with the Geological Survey of India.

Physical Appearance.

Portion A (Plates 18-22), weight 56·689 kilos. This large mass has suffered badly from fracturing, probably on impact and after. The general shape is so well shown in the illustrations that there is no need for further description. The crustal surface (Plates 18 and 22) is almost entirely covered with pits of varying sizes. Many of these are comparatively shallow, the ordinary thumb markings of meteorites. These are often arranged in group separated from each other by well defined but shallow ridges.

The most striking feature of the original surface is the presence of a number of extraordinarily deep depressions (Plate 18, middle). This line of deep depressions is met at right angles by another line, and the second line by a third (Plate 22).

The crust is quite uniform, almost black in colour, and covered by a network of fine black glazed lines.

The fractured surface (Plates 19, 20, 21) shows two noticeable features. First, an obscure rectangular jointing, second, a large number of rust covered surfaces, some plain, some curved and lying at all angles through the mass. These surfaces are seen to penetrate and disappear into the unfractured rock. Some of them can be traced to very considerable distances through the meteorite as thin brownish lines. At first sight, it seemed that these surfaces were similar in origin to the slickensides which are commonly developed in meteorites during fracture. Careful examination showed that this explanation would not account for all phenomena observed. If these were newer slickensides, they would have been confined entirely to the fracture and would not have penetrated the unfractured rock. In selecting a small portion for micro-section, an opportunity offered of seeing what these surfaces would look like, when freshly developed. They are grooved and are steel-grey in colour, and the rusty brown colour of the exposed surfaces is due to oxidation in the moist climate of Calcutta. I have personally little doubt that these planes are really the remainder of an originally brecciated mass of rock.

Portion B. Weight 9·179 kilos, Plates 23, figs. 1 and 2, and 24, figs. 1 and 2. The whole is a portion of a much larger individual. The fractures, Plate 23, fig. 1, right hand bottom corner, Plate 24, fig. 2, left hand, Plate 24, fig. 1, right hand,—are of an older fracture and show a bluish rather shiny covering not scoriaceous like the original crust. There is one oblong slightly grooved area shown in Pl. 24, fig. 2, which resembles an ordinary slickenside. The fresh fracture, Plate 23, fig. 2, shows a light grey rock marked by glistening metallic points and yellowish chrondules. In this fresh fracture there is a band of much darker material running obliquely across. This patch suggests that there is probably differentiation in the rock, but it may be very similar to the brown material described in portion A. The surface illustrated on Plate 23, fig. 1, is fairly uniformly covered by the older and dull crust, the crust being slightly scoriaceous. It is characterised to the left of the ridge by a number of shallow depressions. To the right of the ridge there is a fairly deep thumb mark. In striking contrast to this, is the surface illustrated in Plate 23, fig. 2. To the right of the figure, is the round, almost plain surface which joins these two surfaces. This shows flow lines in the crust just above and to the right of the identification number. The rest of the face is covered by a number of depressions separated by sharp well defined ridges. Some of these indentations are very deep as compared with their area, and one is triangular narrow slit half an inch deep. Plate 24, fig. 1 shows the portion resting on the surface first described. At the top is a part of what was once a much larger surface. It is deeply cut into by thumb marks. In the front lower portion the surface is thumb marked on the left, while the remainder forms a broad and deep depression. At the right centre there is a projecting portion with comparatively deep thumb marks. The lower right hand bottom corner is a fresh fracture, while the top right hand corner is occupied by an older fracture now covered with a darker crust. Plate 24, fig. 2 shows a surface formed by two fractures of different dates. The right hand two-thirds is occupied by an older fracture showing the slickensided portion, while the left one-third is occupied by a fresh fracture, and in this can be seen the light and dark constituents of the meteorite. The two areas can be identified in the figure as they are separated by a well-marked crack Specific gravity 3·728.

Portion E. Plate 26, figs. 1, 2 and 3. Weight ·957 kilos. The portion is roughly pyramidal in shape with one face composed of an older fracture, and with one corner slightly cut off by a newer fracture. Its general appearance is so well shown in the figure so that there is no need of describing it any further. The base, fig. 3, is almost flat and covered with a finely granular crust, differing from the crust of the rest of the meteorite.

Microscopical Examination.

The crust is variable in thickness, approximately ·02 mm. thick and can generally be divided into three parts, a very thin outer layer, dense black and opaque (·01 mm.), a middle, narrow line of a transparent mineral with high double refraction, and an irregular, much thicker inner layer, partially fused and on its inner side blebby in appearance. It is noticeable that where the angular patches of nickel-iron occur, they project through the two inner layers of the crust and show no sign of fusion or even rounding of their angularities. This is sometimes seen with the silicate minerals. Chondrules abutting on the crust sometimes show a straight edge as if part had been fused off.

Chondrules are fairly common, the number varying from part to part. The commonest chondrules are composed of fibres of enstatite, occasionally radiating, but often set at all angles. The fibres are sometimes separated by a cloudy mineral of low double refraction, the cloudiness being partly due to fine black dust. In two cases the enstatite fibres are associated with a network of an almost black mineral. Often these chondrules are surrounded by a reaction rim of a colourless, highly refracting mineral. Some of the chondrules are almost spherical. A large chondrule (Plate 27, fig. 2), with a well-defined reaction rim is composed of a grey mineral of low double refraction (unidentified) entirely clouded over, partly by fine black dust and partly by decomposition of the mineral.

One chondrule is composed of minute lath shaped crystals of a plagioclase felspar showing multiple twinning, the laths being separated by granules of olivine.

Olivine in well shaped crystals is common (Plate 27, figs. 1 and 2). It is colourless and shows no signs of decomposition. These crystals are often separated by a cloudy mineral similar in all respects to that forming the large chondrule mentioned above.

Nickel-iron occurs in angular patches and aggregates throughout the rock. Some of this may be troilite.

One patch of colourless glass has been noticed.

Analysis of the Meteorite.

The following analysis was carried out by Mr. F. R. Ennos, B.A., B.Sc., A.I.C., at the Government Laboratory, London, in November 1923.

The analysis was done according to the method described in the Mineralogical Magazine, Vol. XIX, No. 98, pp. 323-329, September 1922.

About 23 grammes of the meteorite were crushed and separated by a weak magnet into attracted and unattracted portions, weighing 5·7970 grammes and 17·2274 grammes, respectively. Each of these portions was analysed separately. The bulk composition was calculated from the relative weights and analyses of the attracted and unattracted portions.

——	Attracted portion.	Unattracted portion.	Bulk composition.
Fe	66·37	1·97	18·17
Ni	6·64	·20	1·82
Co	·41	·01	·11
Fe	1·03	4·48	3·61
S	·59	2·57	2·07
SiO_2	3·66	44·84	36·88
TiO_2	..	·16	·13
Al_2O_3	..	3·09	2·53
Cr_2O_3	..	·45	·37
Fe_2O_3	..	·36	·27
FeO	1·04	8·88	7·21
MnO	..	·22	·18
CaO	trace	2·22	1·82
MgO	3·91	29·10	23·61
K_2O	..	·08	·07
Na_2O	..	·72	·59
H_2O	..	·47	·35
P_2O_5	·10	·36	·29
Insoluble	16·14	..	..
	99·89	100·18	100·08

Calculated Mineral Composition.

KAl Si_3O_8	·41			
NaAl Si_3O_8	4·98	9·42	Felspar.
$CaAl_2$ Si_2O_8	4·03		
TiO_2		·13	Ti_2O.
$FeO.\ Cr_2O_3$		·55	Chromite.
Fe_2O_3		·27	Fe_2O_3.
$3\ Ca_3P_2O_8.\ CaO$		·67	Apatite.
$Fe_2\ SiO_4$	5·21	29·36	Olivine.
$Mg_2\ SiO_4$	24·15		
$MnSiO_3$	·33		
$CaSiO_3$	1·78	32·78	Bronzite.
$FeSiO_3$	6·14		
$MgSiO_3$	24·53		
Fe	3·61	5·68	Troilite.
S	2·07		
Fe	18·17		
Ni	1·82	20·10	Nickel Iron.
Co	·11		
H_2O.		·35	H_2O.
TOTAL		99·31	

Percentage of Nickel Iron	20·10
Ratio of Fe to Ni in Nickel Iron	10
Ratio of MgO to FeO in Olivine	6·7
,, ,, ,, Bronzite	5·3
,, ,, ,, total ferro. magnesian silicate.	6·0

The above results indicate that the Merua meteorite belongs naturally to group 2, Cronstad Type of Dr. Prior's classification.[1]

[1] G. T. Prior, Min. Mag., 1916, Vol. 18, p. 30. 1920, Vol. 19 p. 61.

STEGODON GANESA (FALC. AND CAUT.) IN THE OUTER SIWALIKS OF JAMMU. (With Plate 28). BY D. N. WADIA, M.A., B.SC., *Geological Survey of India.*

THE fossil remains which are described in the following paper consist of a tusk (left upper incisor), of the extraordinary length of over 10½ ft., together with the maxillary part of the cranium with which it was in organic connection. They were found by the writer in 1922, near the village of Jagti (long. 74° 57′, lat. 32° 47′) six miles due north of Jammu, and are preserved in the Geological Museum of the Prince of Wales College, Jammu.

The fossil occurred in a series of clay beds interstratified with soft incoherent grey sand-rock—a lithological assemblage typical alike of the lower part of the Upper Siwalik stage as well as the topmost part of the Md. Siwalik of the foot-hills zone of Jammu. The tusk was implanted in its deep alveolar cavity in the cranium. The stump of the second right, upper incisor, about a foot in length, was also *in situ* in the upper jaw. The maxillæ bore two large massive molars separated by a strongly concave narrow palatine. No trace was found of any of the mandibular rami although a close search was made for them, nor of any of the lower molars.

The cranium.

The skull unfortunately crumbled when dug out, but from the discolouration produced in the mould of the cranium, it was possible to make out the main outlines of the skull and the great temporal fossæ characteristic of this species of *Stegodon.*[1]

The only bones of the skull which were to some extent preserved were the maxillæ, the palatine, a few plates of the nasal and fronto-parietal regions, and parts of the occipitals with the two condyles. The palate is a flat plate of bone, broad behind and narrowing anteriorly. Measurements of the width of the plate are as follows:—

Anterior width	1·2	in.
Posterior „	3	„
Length „	13	„

[1] *Fauna Antiqua Sivalensis* London, 1846.

The greatest vertical diameter of the occipital condyle is 4·6 inches; its transverse diameter is 3·7 inches. The teeth that are seen in the present fossil are the last, or the 3rd true molars and are well implanted in the palate in deep alveolar cavities. There is no indication of the preceding second molar nor of any of the so-called "intermediate" molars.

Teeth.

The molar is about 10½ inches long, with a maximum width of 4 inches in the middle, the crown being 3·5 inches high above the alveolar rims. The front parts of both the molars are damaged, one, or possibly two, of the most anterior ridges being missing. But from the extension of the socket-cavity and the examination of the embryo-tubercles of dentine, it appears that the total number of ridges could not have been more than ten. In addition there are two aft talons or incipient ridges with 3 small cusps sprouting at the posterior end. The enamel on the dentine is still perfect; the cement is plentiful and fills both the cavities inside the ridges as well as the intervening valleys between them. The number of cusps on any of the ridges does not appear to be greater than 6 or 7, a number which falls considerably short of the specimens of the same species described by Dr. Falconer and Mr. Lydekker; the most posterior talon has 3, the one following that 3 or 4, which in turn is succeeded by a ridge carrying 5 well-defined cusps. The more anterior ridges, formed by the complete fusion of the cusps, are curved, and are more irregular and wider than the posterior ones. All the ridges are well-defined and fairly elevated, though well worn and blunt at the apex. They rest on broad bases with shallow intervening valleys deeply filled with cement. The long axis of the 6th, 7th and 8th ridges is between 3·8 and 4·2 inches and the greatest average width about 0·75 inch. The depth of the valley between the 6th and 7th ridges is 0·37 inch; the intervals between the summits, of the consecutive ridges is about 0·4 inch. There is no mesial cleft or line traversing the crown, a fact which distinguishes the less specialised mastodons from stegodons. The crown of the tooth is flat by wear, and is almost rectangular in front, this and the solitary last molar point to an individual of some age. The plane of wear of the tooth slopes antero-posteriorly and not as in *Stegodon clifti* from the outer to the inner side.

Molars.

Incisor.

The incisor or tusk, the principal part of the present find, though cut up by a number of transverse cracks, is the best preserved part of the fossil. At the thicker proximal end the tooth is ensheathed in a thick bony covering the incisive sheath, portions of which adhere at some places. The external as well as the internal characters of the tooth are accurately preserved, including the structure of the dentine. In its microscopic structure it scarcely differs from ordinary "living" or green ivory, being composed wholly of densely packed bundles of fine fibres, intersecting each other in long circular arcs. The peculiar "engine turned" marks thus produced, which are so characteristic of true ivory, are clearly seen on all transverse sections. The petrification of the distal 3rd part of the tusk is somewhat better than the proximal 3rd.

The following measurements give the necessary dimensions of the tooth :—

	Ft.	In.
Length of the tusk along its concave border . . .	10	7
Length of the chord of its arc	10	3
Vertical diameter near its proximal end	0	8·3
Transverse ,, ,, ,, ,, ...	0	6·4
Vertical ,, one foot from its distal end	0	4·5
Transverse ,, ,, ,, ,, ,, ,, ...	0	3·9
Vertical ,, at the tip	0	3·2
Transverse ,, ,, ,, ,, ...	0	9

Systematic position.

The length, width and the ridge-formula of the upper molars of the present fossil agrees with the species *S. insignis*, Falconer and Cautley,[1] which is distinguished from the other species of the sub-genus by a higher ridge-formula, greater dimensions of length and width and by the plane of wear of the molars being from the anterior to the posterior extremity, as well as by the greater amount of cement filling the intervals between the ridges. Dr. Falconer, however, founded a new species of Siwalik Stegodons—*S. ganesa* which he believed to have arisen from *S. insignis* by a greater differentiation in certain cranial regions and by development of larger incisors—characters which many now regard as indicating nothing more than sex distinctions. According to these observers *S. ganesa* is merely the male of *S. insignis*. The markedly large size of the present tusk is an

[1] *Fauna Antiqua Sivalensis*, London, 1846.

important determining factor, for no other species of *Stegodon* described by Lydekker or Falconer is known to have tusks of greater length than 7 feet. This fact, coupled with the observations, though imperfect, of the cranial structures mentioned before, inclines me to ascribe the fossil to an adult male of *S. ganesa,* Falconer and Cautley.

Stratigraphic position.

The stratigraphic position of the fossil is interesting. As stated above the lithological characters of the beds in which it occurs furnish no certain guide as to the stratigraphical position of the remains and in the absence of other determinable fossils, or of detailed stratigraphic mapping of this area, it is impossible to give the exact horizon of these beds beyond stating that they are removed from the top of the boulder-conglomerate zone by no less than 10,000 feet of intervening strata and are in close proximity to the sand-rock division of the middle Siwalik. In view, however, of the fact that according to the more detailed and careful zoning by Dr. Pilgrim of the upper and middle Siwalik stages of the Salt-Range and the Siwalik hills areas, the lowest horizon of *Stegodon ganesa* may be taken as near the base of the Pinjor zone, we are constrained to the conclusion that either this species of *Stegodon* appeared at an earlier horizon than that in which it has hitherto been found or that the upper Siwalik stage of the Jammu hills has locally attained the unusual thickness of more than 10,000 feet. Perhaps both inferences are in part true and it is possible that the present species should be ascribed to the Tatrot horizon.

ON A COLLECTION OF LAND AND FRESHWATER FOSSIL MOLLUSCS FROM THE KAREWAS OF KASHMIR. (With Plate 29.) BY B. PRASHAD, D.SC., *Officiating Director Zoological Survey of India.*

IN describing the lacustrine Karewa deposits of Kashmir in 1859 Godwin-Austen[1] stated that "In all my wanderings amongst the Karewah-Hills, I never was able to find the slightest trace of a land or freshwater shell in any of the many sections I have examined." Later [2] some molluscs from similar deposits in Kashmir collected by Godwin-Austen were listed by Woodward as being from Kuardo, but none of the species were found as fossils and, with the exception of *G. pankongensis* (Nevill) v. Martens, none of them are represented in Dr. Wright's collections which form the subject of this paper. In 1912 Middlemiss[3] found apparently near the same locality where Dr. Wright's fossils were collected, several examples of *Planorbis* and some unrecognisable fragments of shells. So far as I have been able to trace, no other fossil or subfossil molluscs, whether land or freshwater, have been recorded from the Karewas of Kashmir.

The land and freshwater fossil molluscs described in this paper were collected by Dr. Wm. J. Wright in 1920 in the area lying south of Lat. 34° 10′. All the fossils described below are from a group which Dr. Wright characterised as K-9 in his notes. This bed according to him is approximately 365 feet thick and consists of "chiefly fine buff weathering sandstone and shale," including "beds of dark shale and sandstone near the top." "In one section the group contains considerable dark shale and just below Guravet Khurd there are thin seams of lignite."

The collection is not a large one, in that only five species—three Gastropods and two Pelecypods—are represented, but is very interesting owing to the first find of a Unionid, whether living or fossil, in the Kashmir territory.

[1] Godwin-Austen, *Quart. Journ. Geol. Soc. London*, XV, p. 225 (1859).
[2] Woodward, *Quart. Journ. Geol. Soc. London*, XX, p. 388 (1864).
[3] Middlemiss, *Rec. Geol. Surv., Ind.*, XLI, p. 121 (1912).

I have been able to recognize the following species :—

GASTROPODA.

1. *Bensonia* sp.
2. *Bithynia tentaculata* (Linn.) var. *Kashmirensis* Nevill.
3. *Gyraulus pankongensis* (Nevill) v. Martens.

PELECYPODA.

4. *Corbicula* sp.
5. *Lamellidens* sp.

I am indebted to Dr. E. H. Pascoe, Director, Geological Survey of India, for giving me the opportunity of working out this interesting collection. My thanks are also due to Mr. H. C. Jones, Superintendent, Geological Survey of India, for valuable help in looking up the literature on the subject.

GASTROPODA.

Family ZONITIDAE.

Genus BENSONIA Pfeiffer.

(Plate 29, fig. 1.)

1855. *Bensonia,* Pfeiffer, *Malakozool. Blatt.* p. 119.
1908. *Bensonia,* Blanford & Godwin-Austen, *Faun. Brit. Ind. Mollusca* (Testacellidae & Zonitidae), p. 171.

Dr. Wright collected two specimens of a Zonitid from the north bank of the Kakriaj Nar. Some remains of similar shells were also found in a bed in Square C-2 of Survey of India sheet 43. Unfortunately both the shells are badly broken, and in none of the two the mouth is preserved. The form and sculpture, however, suggest that the fossils probably belong to a species of *Bensonia* nearly allied to *B. monticola* (Hutton).

Family HYDROBIIDAE.

Genus BITHYNIA Leach.

1818. *Bithynia,* Leach in *Abel's Narrative of Journey into Interior of China,* p. 362.

This genus of the family Hydrobiidae or Paludestrinidae is represented in the Kashmir collections by a variety of the widely distributed species *Bithynia tentaculata* (Linn.). This species is common all over Central Europe [1] from Portugal to Amur; in North Europe occurring as high up as St. Petersburg and North Norway; England and Ireland and extending into North America to Canada through Greenland. In North Africa it is said to occur in Algeria and Morocco, and in Asia it has definitely been recorded from Western Siberia, Kashmir and quite recently from Punjab in the Salt Range.[2] The variety from Kashmir and the Salt Range is the one described below as the var. *kashmirensis* Nevill.

As a fossil the species is known from various places in Germany (Kreglinger *loc. cit.* p. 310) and in England it has been found from the Pliocene through Pleistocene to Holocene periods.[3]

BITHYNIA TENTACULATA (Linn.) var. KASHMIRENSIS Nevill.

(Plate 29, figs. 2-5.)

1885. *Bithynia tentaculata* var. *kashmirensis*, Nevill, *Hand-List Moll. Ind. Mus.*, II, p. 39.

Nevill only gave the name *kashmirensis* and the measurements of a specimen of his new variety to specimens from Kashmir (exact locality not stated) and Srinagar. As the variety has never been figured or described, I include here a few notes on its diagnostic characters, and figure the type-shells. The fossils collected by Dr. Wright are quite identical with the type series of Nevill and the specimens collected by me near Srinagar in 1921.

The variety *kashmirensis* differs from the typical form in having all the whorls more tumid, the penultimate and body-whorl being specially marked in this respect; the suture more deeply impressed; the shells slightly more umbilicate; the mouth opening more regularly rounded anteriorly and the shell somewhat thicker.

The fossils of this species were collected from the same locality in which *Bensonia* sp., described above, was found.

[1] See Kobelt, *Rossmassler's Icon. Land und Süssw. Moll.* (*n. f.*) V, p. 63 (1892) and Kreglinger, *Syst. Verzeich. Deutschland Binnen-Moll.*, p. 309 (1870).

[2] Annandale & Rao, *Rec. Ind. Mus.*, XXV, p. 601 (1923).

[3] Kennard, *Proc. Malacol. Soc., London*, XVI, p. 97 (1924)

Family PLANORBIDÆ.

Genus GYRAULUS Agassiz.

GYRAULUS PANKONGENSIS (Nevill) v. Martens.

(Plate 29, figs. 6, 7.)

1922. *Planorbis (Gyraulus) pankongensis,* Germain, *Rec. Ind. Mus.*, XXI, p. 110.

In Dr. Wright's collection there are a number of Planorbids collected with the specimens of *B. tentaculata* var. *Kashmirensis* referred to above. I have no hesitation in referring these to Nevill's species *pankongensis* which was described from Pankong Lake. Specimens of this species from the Kashmir valley are also in the Indian Museum collection.

Weber[1] wrongly considers this to be only a form of *G. glaber* (Jeffr.), as the species is not allied to *G. glaber*, but is, as Nevill rightly pointed out, allied to *G. convexiusculus* (Hutton).

I have little doubt that the records of *P. nanus* by Woodward[3] and of *Planorbis* (*Gyraulus*) *albus* var. and *Planorbis* (*Armiger*) *nanus* by Godwin Austen[4] all refer to this species.

Family CYRENIDAE.

Genus CORBICULA Meg. von Mühlfeldt.

CORBICULA sp.

(Plate 29, fig. 8.)

In the collection there are both the valves of a shell of a species of *Corbicula* collected from near the spring at Gogajipathar. Unfortunately the shells are incomplete and badly compressed, and the hinge is not visible. It is, therefore, not possible to identify the

[1] Weber, *Zool. Jahrb.* (*Syst.*), XXIX, p. 307 (1910).
[2] Nevill, *Scientific Results, Second Yarkand Mission, Mollusca,* p. 10 (1878).
[3] Woodward, *Proc. Zool. Soc., London,* p. 186 (1856) and *Proc. Geol. Soc., London,* XX, p. 388 (1864).
[4] Godwin-Austen, *Proc. Malacol. Soc., London,* III, pp. 260, 261 (1899).

fossils with certainty. The general form and sculpture suggest near-relationship with the known species *C. cashmerinsis.*[1]

Family UNIONIDAE.

Genus LAMELLIDENS Simpson.

1900. *Lamellidens*, Simpson, *Proc. Nat. Mus., Washington*, XXII, p. 854.
1914. *Lamellidens*, Simpson, *Descript. Cat. Naiades*, p. 1165.
1918. *Lamellidens*, Prashad, *Rec. Ind. Mus.*, XV, p. 145.
1919. *Lamellidens*, Annandale & Prashad, *Rec. Ind. Mus.*, XVIII, p. 59.

The genus *Lamellidens* is widely distributed in India and Burma. Forms of the widely distributed species *L. marginalis* (Lamarck) are also known from Afghanistan and Baluchistan. No Unionids have, however, been recorded from the Kashmir territory and when in Kashmir in 1921 I did not, in spite of careful search all over the area, come across any Unionids. It is, therefore, of great interest to record a fossil Unionid from Dr. Wright's collection which can, with little hesitation, be assigned to the genus *Lemellidens*. This discovery completes the link in the chain of distribution of the genus *Lamellidens* which thus extends from Baluchistan, Afghanistan through Kashmir to the Punjab and thence through the Gangetic plain to Assam and Burma on one side and to Peninsular India and Ceylon on the other. No member of the genus has hitherto been found in Sindh.

LAMELLIDENS sp.

(Plate 29, figs. 9, 10.)

In assigning the fossils obtained by Dr. Wright to the genus *Lamellidens* I have been guided by the general facies of the shell, the type of beak and traces of the hinge-line. Unfortunately, the rest of the hinge is not preserved, nor is the external surface of the shells to be seen in the remains of shells in the casts collected. I have, therefore, not attempted to give these fossils a name, but it may be noted that the species is nearly allied to *L. marginalis* (Lam.).

The fossils in Dr. Wright's collection were obtained from north bank of Kakriaj Nar ¼ mile from the east boundary of Survey of India sheet 43.

[1] Deshayes, *Proc. Zool. Soc., London*, p. 344 (1854).

EXPLANATION OF PLATE 29.

LAND AND FRESHWATER SHELLS FROM KASHMIR KAREWAS.

(*All the figures are from direct photographs of specimens.*)

BENSONIA sp.

1. Compressed shell from Kashmir Karewa; natural size.

BITHYNIA TENTACULATA (Linn.) var. KASHMIRENSIS, Nevill.

2, 3. Dorsal and ventral views of two recent shells out of the type-series from Srinagar, Kashmir: × 5.

4, 5. Dorsal view of two fossil shells from the Karewas of Kashmir.

GYRAULUS PANKONGENSIS (Nevill) v. Martens.

6, 7. Dorsal and ventral views of two fossil shells from the Kashmir Karewas × 5.

CORBICULA sp

8. Two valves of a shell from the Kashmir Karewas: × 5.

LAMELLIDENS sp

9, 10. Natural size photographs of two casts with remains of shell-valves.

REPORT ON THE EXAMINATION OF BURMESE LIGNITES, FROM NAMMA, LASHIO AND PAUK. BY C. H. LANDER, D.Sc., DIRECTOR *of Fuel Research, London,* WITH AN INTRODUCTION. BY F. W. WALKER, M.C., B.A., B.A.I. (DUB.), *Assistant Superintendent, Geological Survey of India.*

CONTENTS.

INTRODUCTION.

IT has been known for many years that coal deposits exist in many districts of Burma and that several of these contain considerable quantities. Spasmodic efforts have been made to work some of these deposits but hitherto they have not been attended with success. The production figures are ample proof of this. For the last 5 years the figures, taken from the Records of the Geological Survey of India, are as follows:—

	Tons.
1918	..
1919	1,500
1920	..
1921	300
1922	172

There are two main reasons for this small production, (1) inaccessibility of many of the deposits, (2) the poor quality of the coal. If the material exists in quantity the former presents no difficulty. As to the latter, the majority of the coal of Burma is "lignite" or "brown coal" which has high moisture and ash contents and small fixed carbon. The calorific value is low in consequence.

Most lignites, before they can be used successfully as a fuel have to undergo a process of treatment, which varies according to the composition of the raw material and also on the manner in which the fuel is to be employed. When used for power production it is necessary to fit special types of grates and hearths, and, stoking has to be carefully regulated.

Methods of treating Lignites.

The chief methods of treating lignites are :—air drying, briquetting, distillation, and gasification. Air drying is the simplest as the fuel is used in the natural state after a proportion of the excess moisture has been driven off. Briquetting entails elaborate machinery as the lignite has to be crushed, screened, dried and then moulded into briquettes under great pressure. It is the commonest form of treatment for a powdery coal. Distillation is suitable for lignites which have a high content of bituminous matter. Oil, gas and coke are the chief products obtained. Gasification is employed when the percentage of bituminous matter is small. The producer-gas obtained can be utilised either direct in gas engines or to fire boilers.

Compared with ordinary bituminous coal, the exploitation of lignite is beset with considerable difficulties.

Scope of Examination.

When the question of testing the Burmese lignites was raised by the Government, it was hoped that samples from all the coal fields would be included in the experiments but, when the cost was ascertained, it was found that there were only sufficient funds for three complete tests. The Geological Survey were asked to select the three fields and to collect the necessary samples. The three fields considered to be of most economic value were accordingly chosen, namely :—Namma, Lashio and Pauk. The selection was a matter of considerable difficulty as the available information on these fields contained no estimate of quantity. The Kalaw and Henzada fields were considered to be outside the scope of the enquiry as these are true coals as distinct from lignite; the former being a Jurassic coal and the latter approaches the composition of an anthracite and is probably also of Jurassic age.[1] Examination of the other important deposits will have to await the allocation of further funds.

Location of the fields sampled.

The Namma field lies on the southeast side of Lashio and extends to within 10 miles of the town, covering about 50 square miles. It was visited by Neotling in 1891.[2] A more detailed examination of the field was made by Simpson in 1905.[3] There appear to be two

[1] Cotter, The Mineral Deposits of Burma, p. 18.
[2] Noetling, *Rec. Geol. Surv., Ind.*, Vol. XXIV, pp. 116-119.
[3] Simpson, *Rec. Geol. Surv., Ind.*, Vol. XXXIII, pp. 125-144.

seams of economic value, one of which varies in thickness from 7 to 17 feet and over a proved distance of 2,400 feet is estimated to contain half a million tons. The coal seams are interstratified with soft beds of clayeyshales which would render mining operations difficult. The age of the beds is considered to be late Tertiary; probably Pliocene. The distance from Lashio railway station by cart-road is 25 miles.

The samples from this field were taken from the north-east incline of the two driven by the Burma Corporation, east of Namma.

Lashio is the present terminus of the Northern Shan States branch, Burma Railways. The coal deposits are found some 5 miles north of the town. Noetling visited this field also in 1891[1] but LaTouche and Simpson conducted excavations and made a thorough examination later.[2] In this field also, the coal is interbedded with beds of sandy clays and soft sandstones and all lie below the level of permanent saturation. Seams varying in thickness from a foot to 33 feet were found. The age of the coal strata is thought to be late Tertiary also.

The samples from this area were taken from the bed of the Nam Yau river, half a mile west of the village of Hsunkwe and 1¼ miles north-west of the bridge on the cart road from Lashio to Nam Hkam.

The Pauk field is situated in the Pakokku district about 50 miles west of the Irrawaddy. The coal seams outcrop in the neighbourhood of the Yaw river some 14 miles south-east of Pauk, the town from which the field takes its name. A complete examination of the field was made by Cotter in 1913.[3] The coal-bearing rocks belong to the Shwezetaw stage, the age of which is Lower Oligocene.[4] Consequently this field is older than the Namma and Lashio fields.

The samples were taken from three outcrops, the exact location of which will be found in the references given.

(1) Newè chaung, excavation No. 1.[5]

(2) Thongwa chaung, middle seam.[6]

(3) Yekyin chaung, excavation No. 2.[7]

All the samples were packed into empty kerosine oil tin and sealed in the field.

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[1] Noetling, *op. cit.*, pp. 112-116.

[2] LaTouche and Simpson, *Rec. Geol. Surv., Ind.*, Vol. XXXIII, pp. 117-124.

[3] Cotter, *Rec. Geol. Surv., Ind.*, Vol. XLIV, pp. 163-185.

[4] Vredenburg, *Rec. Geol. Surv. Ind.*, Vol. LII, p. 364.

[5] Cotter, *op. cit.*, p. 180.

[6] Cotter, *op. cit.*, p. 178.

[7] *ibid*, p. 170.

Analysis of samples from Namma and Lashio in the Geological Survey Laboratory.

Samples from Namma and Lashio collected at the same time as those for the Fuel Research Board tests gave the following results on analysis in the Geological Survey Laboratory, Calcutta :—

—	Namma. Per cent.	Namma. Per cent.	Lashio. Per cent.
	1	2	3
Moisture	23·74	24·16	35·70
Volatile matter	36·50	35·04	33·00
Fixed Carbon	36·36	36·60	24·76
Ash	3·40	4·20	6·54
	100·00	100·00	100·00
	Does not cake.	Does not cake.	Does not cake.
Ash	Brown.	Brown.	Reddish Brown.

PRELIMINARY EXAMINATION OF BURMESE LIGNITES.

Samples.

The various samples had all been sealed in petrol tins on despatch, but many of these had been eaten through in small holes by rust during the transport period. As the tins were also tightly packed in wooden cases it was hoped that what little access of air there was to these holes would not seriously affect the lignite itself. On visual examination no difference between similar lignites in sound or damaged tins could be detected.

The following descriptions of the various samples were obtained from the labels and from correspondence.

Namma Coal Fields—
Northern Shan States . . . 4 tins = 120 lbs. lignite.

Lashio Coal Fields—
Northern Shan States . . . 4 „ = 85 „ „

Pauk Coal Fields—
(1) Yekkyin stream . . . 4 „ = 125 „ „
(2) Thongwa stream . . . 4 „ = 135 „ „
(3) Newè stream . . . . 4 „ = 140 „ „

The samples from the Pauk coalfields were taken from localities described in the Records of the Geological Survey of India, Vol. XLIV, pp. 163-168.[1]

Yekkyin stream . . .	Excavation 2 . . .	p. 170.
Thongwa „ . . .	Sample 20	p. 178.
Newè „ . . .	Mixed Sample 18 and 19 .	p. 180.

It was not considered necessary by the Superintendent of the Geological Survey (India) that the three samples from the Pauk fields should be each examined in full as they were likely to have very similar characteristics, but that a preliminary examination should be made to make certain of this.

PRELIMINARY EXAMINATION.

It was decided to carry out a preliminary investigation on each of the 5 samples and then arrange a further programme of work when the results had been considered.

The preliminary investigation consisted of :—

(1) Visual examination.
(2) Proximate analysis.
(3) Assay at 600°C.

VISUAL EXAMINATION.

Namma.—The samples consisted entirely of fairly large pieces, in appearance similar to a dull pitch. Some of the pieces were covered with a brownish incrustation. On fracturing a dull black surface was obtained, but the lumps had no distinct partings and were not particularly brittle.

Lashio.—This sample was also in the form of fairly large lumps and these were covered with dark red incrustation. On fracturing, the material was found to be in distinct layers with dark reddish partings. The lignite itself was dull and differed from the others in showing no glossiness or resemblance to pitch.

Pauk, Yekkyin Chaung.—The sample was in the form of small nuts partially covered with a brownish incrustation. The lumps

[1] Some newly discovered coal-seams near the Yaw River, Pakokku District, Upper Burma by G. de P. Cotter, *Rec. Geol. Surv., Ind.*, Vol. XLIV, pp. 163—185.

were very brittle and the clean surface was very similar in appearance to bituminous coal but without partings.

Pauk, Thongwa Chaung.—The sample consisted of fairly large pieces mixed with a considerable percentage of dust, the pieces being partly covered with a brown or white incrustation. The lumps were very brittle and had a glossy and pitch-like fracture Small pieces of colourless resin were also present.

Pauk, Newè Chaung.—The sample consisted of very small pieces, with brownish red incrustation. The pieces were very brittle, giving a fairly glossy, pitch-like surface. Distinct partings of a dark silvery appearance and apparently crystalline, were observed

ANALYSIS.

The proximate analyses of the five samples are shown in Table 1.

The high moisture content of all five, and particularly of that from Lashio is noticeable.

The ash contents of all except the Namma sample are also high, varying from 9·4 to 17·6 per cent on the dry lignites, the Newè Pauk sample having the highest value.

The volatile matter on the ash-free dry lignites varied from 48·8 to 58·1 the three Pauk samples showing fairly close agreement within 2 per cent of one another.

The calorific value of the lignites were as follows in B. Th. U's per lb. :—

—	Moisture per cent.	Sulphur per cent.	Calorific value.	Dry calorific value.
Namma	25·54	0·86	7,800	10,460
Lashio	36·18	1·85	5,460	8,540
Pauk, Yekkyin . . .	17·18 }	2·43	6,590	8,160
„ Thongwa . . .	21·20 }			
„ Newè . . .	18·22	2·83	6,680	8,170

ASSAY AT 600°C.

This was carried out on the dried lignites according to the method described in Technical Paper No. 1 of the Fuel Research Board

The figures obtained are shown in Table 2, and the following conclusions may be drawn from them :—

(1) The coke formed was in each case a black non-coherent powder amounting to about 60 per cent.

(2) The yield of tar was low, even for lignites and varied from 9·4 to 16·6 gallons per ton of dry lignite or from 11·4 to 18·0 gallons on the lignite substance.

(3) The yield of gas was in each case high and of the composition shown in Table 3. The high percentage of CO_2 in these gases is noticeable and gives the gas a high specific gravity. The calorific value is still, however, fairly high owing to the presence of saturated paraffin hydrocarbons.

CONCLUSIONS.

1. A further programme of work is being drawn out to complete the examination of these lignites.

2. It will be necessary to examine the Newè Pauk sample separately from the other two as it differs considerably in its tar yield on distillation. The other two Pauk samples are sufficiently similar to be examined together.

TABLE I.—*Proximate Analyses.*

—	*Namma.*	*Lashio.*	PAUK COALFIELDS.		
			Yekkyin.	Thongwa.	Newè.
As received—					
Moisture	24·54	36·18	17·18	21·20	18·22
Volatile matter less moisture.	34·94	31·66	38·12	36·98	35·40
"Fixed carbon"	36·65	22·80	36·90	33·46	31·98
Ash	3·87	9·36	7·80	8·36	14·40
			100·00		
Calculated to dry lignite—					
Volatile matter	46·30	49·61	46·02	46·93	43·28
"Fixed carbon"	48·57	35·72	44·56	42·46	39·11
Ash	5·13	14·67	9·42	10·61	17·61
			100·00		

TABLE I.—*Proximate Analyses.*—contd.

	Namma.	*Lashio.*	PAUK COALFIELDS.		
			Yokkyin.	Thongwa.	Newè.
Calculated to dry ash-free lignite—					
Volatile matter . .	48·80	58·14	50·80	52·50	52·53
"Fixed carbon" . .	51·20	41·86	49·20	47·50	47·47
		100·00			

TABLE 2.—*Laboratory Low Temperature Assay at 600°C.*

Sample.	GRAMMES PER 100 GRS. DRY LIGNITE.					GAS.		
	Coke.	Gas.	Oils.	Liquor.	Total.	NH_3 in liquor per 100 grs. dry lignite.	S. G. (air=1).	CC/100 grs. dry lignite 60°F and 30" satd.
Namma . .	60·5	21·5	5·0	13·3	100·3	..	0·984	17,540
Lashio . .	57·5	25·4	5·5	11·5	99·9	0·229	1·015	20·540
Pauk—								
Yokkyin . .	62·5	18·1	7·4	11·5	99·5	0·141	0·979	15,280
Thongwa . .	63·2	16·2	6·7	14·0	100·1	0·162	0·88	15,160
Newè . .	64·3	17·4	4·2	14·2	100·1	0·161	0·965	15,060

Coke.—Coke was in each case a black powder; no cohesion of the particles.

Yields per ton of dry lignite.

—		*Namma.*	*Lashio.*	PAUK COALFIELDS.		
				Yekkyin.	Thongwa.	Newè.
Coke	cwts.	12·10	11·50	12·50	12·64	12·86
Tar	galls.	11·20	12·32	16·58	15·00	0·41
Liquor	,,	29·8	25·8	25·8	31·4	31·8
Gas	cu.ft. .	5,590	6,460	4,870	4,840	4,800
	therms .	10·6	20·0	20·4	20·5	16·3
S. Ammonia	lbs.	..	19·8	12·3	14·1	14·0

Behaviour on distillation.

Sample.	Apparent temperature of decomposition °C.	Observations.
Namma	280-290	Gas evolution commenced at 280°, and oils could be observed in silica tube at 300°. Brown oily liquid was condensed at end of silica tube at 330°, when gas evolution was rapid. At 370-380° oil condensed in receiver.
Lashio	250	Gas evolution was rapid at 250°. Oil vapour was observed in silica tube at 260°. Opalescent liquid condensed in receiver at 300°. At 325° the gas evolution was extremely rapid. Oil was condensed in receiver at 340°. Wax-like material condensed in receiver at 370°.
Yekkyin, Pauk	280	Much slower evolution of gas to begin with than with previous samples. Slight opalescent liquid in receiver at 280°. Oil drops observed in silica tube at 310°. Wax-like material condensed in receiver at 390°.
Thongwa, Pauk	290	Gas evolution commenced at 290°. Oily drops could be observed in Silica tube at 310° when gas evolution was rapid. Oil was condensed at end of Silica tube between 310° and 380°. Brown waxy material was condensed in receiver at 380°.
Newè, Pauk	280	At 280° opalescent liquid condensed at end of silica tube ; no oil drops visible. Gas evolution was rapid at 310°. Oil condensing at end of silica tube at 330°. Oil condensing in receiver at 390° and brown waxy material condensed in receiver at 400°.

TABLE 3.—*Analyses of gas from Assay at 600°C.*

Sample.	*Namma.*	*Lashio.*	PAUK COALFIELDS.		
			Yekkyin.	Thongwa.	Newè.
CO_2	40·70	47·05	37·75	39·20	45·50
C_nH_m	1·35	1·55	2·00	2·45	1·45
O_2	1·45	1·30	1·70	1·25	1·45
CO	16·45	12·50	13·65	11·50	10·15
H_2	10·05	15·05	13·75	15·90	14·65
C_nH_{2n+2}	23·15	15·15	27·45	24·65	19·35
N_2	6·85	7·40	3·70	5·05	7·45
	100·00	100·00	100·00	100·00	100·00
"n" in satd. hydrocarbons	1·00	1·11	1·06	1·21	1·12
Cal. value B. Th. U's cubic feet	350	310	420	425	330

SEMI-LARGE SCALE CARBONISATION OF BURMESE LIGNITES.

Samples.

Following on the examination of the samples in the laboratory it was decided that semi-large scale carbonising trials should be carried out on four samples representative of the following localities :—

(1) Namma Coal Fields, N. Shan States.
(2) Lashio ,, ,, ,,
(3) Pauk ,, ,, , Yekkyin and Thongwa streams.
(4) Pauk ,, ,, , Newè stream.

Two of the samples from the Pauk fields were examined together as they had very similar characteristics. The other differed somewhat in giving in the laboratory a low tar yield and was treated separately.

The plant available at the Research Station for the work was a single retort of the bench of horizontal, mild-steel retorts specially designed for experimental work on low-temperature carbonisation. This single retort had been specially fitted with its own condensing, scrubbing and gas measuring plant for the purpose of dealing with small quantities (100-200 lbs.) of coal.

Using British coal many satisfactory experiments have been carried out on this retort in which the weights of products collected were within one per cent of the weight of coal carbonised.

The four lots of lignite, of about 100 lbs. each, were accordingly carbonised in turn in this retort and the products measured and examined. Unfortunately no surplus lignite was available for preliminary work and only one run could be carried out on each sample.

The temperature employed was 600°C., *viz*: that already shown on a small scale to be the most suitable.

The results obtained are detailed in Table 1 which shows actual figures on the lignite as charged and in Table 2 where the yields per ton of dry lignite (dry at 105°C.) are compared with those of the laboratory assay apparatus.

In carrying out the carbonising tests no difficulty was experienced until the tar and liquor were collected for separation. Then it was found that the tar had solidified along the pipes and was extremely difficult to collect quantitatively. Finally, it was necessary to steam out the system after each run to recover as much tar as possible. As the total yield, in any event, was very small this led to a distinct loss of tar, which, as shown later, would appear to be very serious. If more lignite had been available for treatment there is no doubt that this difficulty would have disappeared on carbonising a larger amount, but, unfortunately, this expedient was impossible.

CARBONISING RESULTS.

Charge.

About 100 lbs., of air-dry lignite was treated in each run, the size of the material as charged ranging from half-inch pieces to dust.

Carbonisation was continued until the gas yield had fallen off to a sufficiently low rate to indicate that the coke was exhausted. The total time required was approximately four hours.

No difficulties were experienced in the actual carbonisation except, as already stated, in the recovery of tar from the system.

WEIGHT BALANCES.

The weight balances were very unsatisfactory in that, on the average, they showed a loss from the system of 8·4 per cent. That this loss is principally tar may be deduced from the following comparison, on a percentage basis, with laboratory results, but it is unfortunate that the shortage of material rendered it impossible to carry out confirmatory experiments.

Lignite as charged to horizontal retort.

	Coke.	Gas.	Tar.	Liquor.	TOTAL.
Average of horizontal retort tests.*	47·8	11·8	1·3	30·7	91·6
Average of laboratory tests.*	46·2	15·4	4·1	34·2	99·9

* Results calculated to same moisture content.

The lower coke and higher gas yields in the laboratory tests were occasioned by the fact that the coke was more completely exhausted, and also that on the larger scale it is difficult to prevent absorption of CO_2 in the gas holder.

The outstanding difference is therefore in the yield of tar, and it may be assumed as already stated that the small quantity of lignite dealt with and the small yield of tar available, have rendered the percentage losses excessive, though the real losses were not great. The solid and sticky nature of the tar is also to blame for much of the difficulty experienced in recovering the whole of the small quantities produced.

PRODUCTS OF CARBONISATION.

The yields and properties of the products of carbonisation are described below :—

Coke.

The coke produced from each lignite was very similar in appearance to that of a fresh surface of the lignite itself, except that the structures of the lumps were broken up by innumerable small cracks. Shrinkage in size had also taken place and the texture of the coke appeared very close and hard except with the Lashio lignite which gave a coke somewhat similar in appearance to hard charcoal.

All the cokes were free burning and give a hot fire with a fair volume of smokeless flame.

The calorific value of the dry coke varied from 11,500 to 12,500 B. Th. U's per lb., this low value being occasioned by the high percentage of ash. On the ash-free basis the gross calorific value available appears to be about 14,200 B. Th. U's per lb., which compares with about 14,500 for ash-free dry low-temperature coke made by the carbonisation of bituminous coal.

As no lignite was available in large pieces the burning properties of the coke could not be more fully investigated.

The proximate analyses of the cokes are shown in Table 3. The volatile matter still remaining is rather high and should be reduced, in any large-scale carbonising process, to about 10 per cent.

Gas.

As shown in Part I of this report, gas is first liberated at a temperature of from 250 to 280°C., and the evolution is very rapid up to 330°C.

In a retort where the lignite is immediately subjected to the full temperature, rapid evolution of gas is obtained very soon after charging. This rush soon exhausts itself and gas evolution proceeds slowly over quite long periods. In the horizontal retort a period of 4 hours was necessary to reduce the volatile matter in the coke to about 15 per cent. At the end of this period the rate of gas evolution was equivalent to 20 cubic feet per ton per minute.

The gas as collected contained a large amount of carbon dioxide, between 40 and 50 per cent, but burned readily with a blue flame having a luminous tip. The calorific value as collected varied from 370 with Lashio to 490 with Yekkyin and Thongwa Pauk lignites. Calculated to a "free from CO_2" basis the gross calorific value is as high as 740 B. Th. U's per cubic feet on the average.

The total yield of gas available is shown in the following table as calculated per ton of dry lignite :—

Lignite.	Total gas cubic feet.	Gas free from CO_2 cubic feet.	Therms.
Namma	5,090	2,940	21·0
Lashio	4,590	2,680	17·1
Pauk, Yekkyin and Thongwa	4,050	2,390	19·8
Pauk, Newè	3,960	1,880	14·8

The analyses of the four gases made are shown in Table 4. Apart from their high CO_2 content they are remarkable in having a high percentage of saturated hydrocarbons. The mean value of "n" in the expression C_nH_{2n+2} is 1·25 showing that these hydrocarbons consist mainly of methane with about one third as much ethane and traces of propanes, etc.

Condensible hydrocarbons in gas.

A scrubbing experiment was carried out on the gas obtained from the Namma lignite. This was conducted in such a way as to give the maximum yield of condensible spirit.

Volume of gas scrubbed	= 40 cubic feet.
Wash oil used	= 3·1 litres.
Yield of spirit	= 22·2 ccs. or 0·62 gallons per ton of dry lignite.

The refined spirit is a mobile, colourless liquid, of specific gravity 0·797 at 15°C., which turns yellow on standing.

Liquor.

The liquor recovered by the carbonisation of lignite contains an appreciable quantity of ammonia, but it is unlikely that this would ever repay recovery. Normally, lignite has a high moisture content and, when carbonised, large quantities of water are liberated in the early stages. For this reason the ammonia concentration is much too low for efficient recovery. With the samples under investigation the average yield of liquor amounted to 68·7 gallons per ton of lignite as charged. The percentage of ammonia in this liquor was about 0·27, or only one sixth of that which, at the present time, is regarded as strong enough to justify recovery. If the lignite were charged dry the yield would have been 29 gallons at a strength of 0·64 per cent NH_3, which would also be too low for recovery.

The analysis of the liquor collected from each lignite is shown in Table 5.

Tar.

As already stated, the yields of tar were very disappointing. Shortage of lignite prevented the carrying out of repeat tests as would otherwise have certainly been done.

The reasons for the low yields have already been surmised on page 372 but definite conclusions do not appear possible.

The actual yields calculated as gallons per ton of dry lignite are shown below in comparison with those of the laboratory experiments. Experience with the laboratory apparatus has shown that a bituminous coal will yield 66 per cent more tar in it than in the experimental horizontal retort. If this same factor were assumed for lignite, which is not unreasonable, the results obtained should have been as shown in the second column.

Tar yields in gallons per ton of dry lignite.

	Laboratory yield.	Predicted yield in hor. retort.	Yield in hor. retort.
Namma	11·20	6·72	2·82
Lashio	12·32	7·39	2·34
Pauk, Yekkyin and Thongwa . . .	15·79	9·47	7·65
Pauk, Newè	9·41	5·65	1·83

From this it is apparent that only half of the predicted yield was realised.

In spite of this discrepancy it was decided to carry out a certain amount of examination of the tar.

The samples as collected were in all cases very similar in appearance, being brownish black, semi-solid and having an unpleasant smell. When cold they set to an almost black solid of a waxy appearance which seemed to contain soft crystals. When warmed they became quite fluid at 30° C.

The examination of the tar was only possible on the mixed samples, owing to the small amount recovered in the other cases.

A preliminary distillation was carried out and the resulting fractions were examined separately by washing with sulphuric acid and caustic soda for basic and acid bodies. The refined oils were then distilled and the tar acids separated, washed, and fractionated.

The results of this examination are shown in Tables 6, 7, 8 and 9. These give some idea of the nature of this lignite tar. More elaborate examination was not attempted owing to the doubt which attached to the yields and the fact that the unsatisfactory collection of the samples may have resulted to some extent in an alteration of the distribution of the various products in the tar.

"Montan Wax".

The percentage of montan wax in the Namma lignite was determined and found to be approximately two per cent on the dry lignite. It is doubtful whether so small a yield would justify recovery, but this would depend largely on local conditions and supplies of other waxes.

SUMMARY.

Five samples of Burmese lignite from the Superintendent of the Geological Survey of India were examined at the Fuel Research Station.

These samples represented three different coal fields, there being three separate samples from one field.

(1) Namma Coal Field, N. Shan States.
(2) Lashio " " " "
Pauk " "

(3) Yekkyin stream.
(4) Thongwa stream.
(5) Newè stream.

All five samples were fully examined in the laboratory and the results are given in Part I of this report.

The investigation was completed by the carbonisation of samples of about 100 lbs. each in a steel horizontal retort. In this case samples (3) and (4) were treated together as a mixture, as their properties were very similar.

The results of the carbonisations are discussed in this report and the full examination of the products is also shown.

The yields of tar actually obtained were very low and the examination must be considered as unsatisfactory in this respect. It seems probable that the whole of the tar was not collected, but the amount of lignite available was insufficient for repeat experiments. The nature of the average tar as collected has been investigated to some extent and the results given.

The other products gave more satisfactory yields.

When the dry lignite is considered as a basis no great differences exist in the yields obtainable by a carbonisation process. These yields are most readily compared by consulting Table 2 and may be summarised as follows:—

Yields per ton of dry lignite.

Coke	11 to 13 cwts.
Gas	4,000 ,, 6,000 cubic feet.
or	15 ,, 21 therms.
Tar	5 ,, 10 gallons.
Liquor	Too weak for recovery of ammonia.

The Namma and Lashio deposits give average yields of volatile therms, (gas and tar) while the Pauk deposits are richer in the Yekkyin and Thongwa streams and poorer in the Newè stream.

It is not possible to draw full and definite conclusions from the examination of Burmese lignites which were carried out at H. M. Fuel Research Station, East Greenwich, owing to the limited samples available. The following tentative remarks, however, may be of assistance to those who are commercially interested in the development of the natural fuel resources of the country. The sample from the Namma field consisted of fairly large pieces and the strength of these and the absence of partings seemed to indicate, that this lignite was strong enough to stand handling,* and that, as mined, the percentage of fines or slack would not be excessive. The sample from the Lashio field was brittle and the larger pieces contained partings which gave them a tendency to ready disintegration. The samples from the Pauk coalfields were also brittle and contained a high proportion of fines.

So far, therefore, as it is possible to draw conclusions from the small samples under examination it would appear that for direct use as a fuel the most satisfactory would be Namma lignite and that the others would tend to contain, after handling and transport, a high proportion of slack or dust.

The calorific values of the lignite as mined varied from 5,500 to 7,800 B. Th. U's per lb. or from 9,040 to 10,880 B. Th. U's per lb. on the ash-free dry fuel.

If the lignites were subjected to a process of carbonisation the chief problem would be the supply of heat to the settings and the suitability of the resulting coke. The heat available in the form of gas amounts to only 15 to 21· therms * per ton of lignite and of this approximately 5 therms would be required for the removal of the moisture alone. It is doubtful, but just possible, that a system could be devised in which the gas made would be sufficient to carry on the process. The tar yielded would vary from 5 to 10 gallons (60 per cent of the "assay" yield) per ton of lignite and would serve as a source of fuel oil.

The coke produced would vary considerably. From a strong lignite such as Namma the pieces would probably remain approximately in the shapes and sizes charged, but would be friable owing to the presence of innumerable cracks. With the more brittle and dusty lignites it does not seem possible that the coke could have any application as a sized fuel. On the other hand, however, it would seem to be a favourable material for use as a pulverised fuel.

It is possible that a robust fuel might be obtained by subjecting the material to some process of briquetting followed by carbonisation. This briquetting might take the form of compression without added binder or of briquetting with a suitable binder could one be obtained locally. On the laboratory scale the material yields good briquettes with pressure alone and little disintegra-

*1 therm = 00,000 B. Th. U.

tion is apparent during subsequent carbonisation. It does not follow, however, that the fuel would not disintegrate during carbonisation when the processes are on the full scale. If such a process proved possible the resultant fuel would possess properties such as higher calorific value and would be more suitable to withstand transport than the raw lignite. This however could only be proved by work on the large scale.

TABLE 1.—*Results of carbonisation of 100 lbs. lignite at 600°C.*

—	NAMMA.	LASHIO.	PAUK.	
			Yekkyin Thongwa.	Newè.
Coke lbs..	45·7	37·4	53·2	54·9
Tar „	1·0	0·7	2·9	0·7
Liquor „	31·0	38·2	24·2	29·4
Gas „	13·3	10·0	11·4	11·7
TOTAL YIELD	91·0	87·2	91·7	96·7

TABLE 2.—*Yields per ton of dry lignite in comparison with laboratory results.*

—		Coke.	Tar.	Liquor.	GAS		Ammonia-sulphate lbs.
					cu. ft.	therms.	
		cwts.	gals.	gals.			
Namma	H.	12·2	2·82	..	5,090	21·0	7·5
	L.	12·10	11·20	29·8	5,590	19·0	..
Lashio	H.	11·7	2·34	..	4,590	17·1	13·0
	L.	11·50	12·82	25·8	6,400	20·0	19·8
Pauk, Yekkyin & Thongwa	H.	13·1	7·05	..	4,050	19·8	10·1
	L.	12·57	15·79	28·6	4,855	20·4	13·2
Pauk, Newè	H.	13·7	1·83	..	3,960	14·8	7·5
	L.	12·86	9·41	31·8	4,800	16·3	14·0

H. Horizontal retort result.
L. Laboratory result.

TABLE 3.—*Analyses of coke samples.*

Lignite.	NAMMA.	LASHIO.	PAUK. Yekkyin Thongwa.	PAUK. Newè.
Moisture	3·06	4·03	2·83	2·51
Volatile matter less moisture	15·10	18·85	15·46	13·98
"Fixed carbon"	74·37	57·56	68·34	64·93
Ash	7·47	19·56	13·37	18·58
		100·00		
Volatile matter on ash-free dry coke	16·9	24·7	18·4	17·7
Calorific value B. Th. U's per lb.	13,100	10,960	11,920	11,140
Calorific value, dry, ash-free	14,650	14,350	14,220	14,110
Sulphur, per cent	0·87	2·19	3·16	4·37

TABLE 4.—*Analyses of gases.*

Composition—				
CO_2	42·3	41·6	41·0	52·6
CnH_m	1·7	2·7	3·1	2·0
O_2	0·3	0·6	0·4	0·5
CO	9·2	6·6	6·7	3·5
H_2	12·8	13·0	12·2	12·5
CnH_{2n+2}	26·5	20·5	27·4	19·6
N_2	7·3	15·0	9·3	9·3
	100·1	100·0	100·1	100·0
"n" in satd. hydrocarbons	1·15	1·33	1·25	1·24
Specific gravity (air=1)	1·02	1·10	1·03	1·06
Calorific value (gross) B. Th. U's per cu. ft.	413	372	490	374
Calorific value free from CO_2	716	637	830	789

TABLE 5.—*Analyses of liquor samples.*

—	NAMMA.	LASHIO.	PAUK.	
			Yekkyin Thongwa.	Newè.
Specific gravity at 15°C.	1·008	1·014	1·013	1·008
Ammonia per cent	0·21	0·25	0·39	0·24

TABLE 6.—*Examination of tar (mixed samples).*

Specific gravity		1·05
Setting point	deg. C.	30·0
Distillation by weight—		
To 170°C.		1·8
170 to 230°C.		13·2
230 to 270°C.		14·8
270 to 330°C.		22·3
Pitch		46·2
Loss		1·7
		100·0

TABLE 7.—*Refining of lignite tar fractions.*

Fraction.	0-170°C.	170°-230°	230°-270°	270°-330°
Loss on extraction as percentage by volume of fraction—				
Caustic Soda	12·4	44·5	40·4	16·0
Sulphuric Acid	49·6	13·5	5·1	9·0
Washed Oil Remaining	38·0	42·0	54·5	75·0
Washed and Refined oil	27·0	29·6	46·5	63·0

NOTES.—The high percentage of low boiling unsaturated bodies is noticeable. The fraction 170-270 is rich in phenolic bodies.

TABLE 8.—*Distillation ranges of refined oils.*

1st Fraction.	2nd Fraction.	
	Temperature	Per cent.
68·5 per cent distilled from total up to 170°	To 180°	3·6
	„ 190	5·5
	„ 200	10·9
	„ 210	19·3
	„ 220	27·8
	„ 230	36·6
	„ 240	46·1
	„ 250	52·2
	„ 260	57·8
	„ 270	62·2
	„ 280	65·2
	„ 290	67·8
	„ 300	70·5

TABLE 9.—*Distillation ranges of refined oils.*

3rd Fraction.		4th Fraction.	
Temperature.	Per cent.	Temperature.	Per cent.
To 230° . . .	7·2	To 270° . . .	6·8
„ 240 . . .	14·4	„ 280 . . .	18·0
„ 250 . . .	28·0	„ 290 . . .	26·8
„ 260 . . .	41·6	„ 300 . . .	37·6
„ 270 . . .	52·8	„ 310 . . .	48·8
„ 280 . . .	64·0	„ 320 . . .	58·4
„ 290 . . .	72·8	„ 330 . . .	65·2
„ 300 . . .	79·6	„ 360 . . .	83·2
„ 310 . . .	85·2		

TABLE 10.—*Distillation ranges of tar acids from fraction 170—270°C.*

——	Per cent by volume.	REMARKS.
To 180°	1·0	
„ 190	2·4	Distillation points.
„ 195	5·2	At 200·2
„ 200	11·6	200·5.
„ 205	23·2	202
„ 210	35·0	205
„ 220	57·0	Some phenol present; high proportion of Cresols.
„ 230	63·0	
„ 270	82·6	B. Pt. Phenol 183 deg. C. o Cresol 191 „ m „ 200·5 „ p „ 201 „

THE MAURYPUR SALT WORKS. BY J. A. DUNN, B.SC., D.I.C., F.G.S., *Assistant Superintendent, Geological Survey of India.*

Introduction.

THE method of salt recovery used at Maurypur differs considerably from the usual processes and, as it appears not to have been previously described, a short account of it may be worthy of record.

The salt works are about 8 miles west of Karachi on the seaward edge of the Moach plain. Some 1,800 acres of this plain lie between the high water mark of the fortnightly spring tides and the still higher tides of June and December; of this area 180 acres form the present salt works.

The climate is almost ideal for rapid solar evaporation. The mean annual rainfall at Karachi is only 7·64 inches, normally distributed over 9 days; generally the air is comparatively dry and seldom still; while the mean daily maximum temperature is 84°F.

Method of salt recovery.

The works are surrounded by an earthwork ("bund") 8 feet high as a protection against flooding during storms or abnormally high tides. Along the seaward edge of this a trench, 2,200 yards long, 7 feet wide and 4 feet deep, has been excavated. This communicates with the sea and supplies sea water through sluices to similar trenches within the works. The main inside trench has been cut completely round the inner side of the "bund." The total length of trenches within the works is 5,800 yards. Letting to the salt workers ("lunaris") is done by plots, each consisting of 20 salt pans, 29 feet square. The pans are surrounded by small "bunds," a few inches high, made from a fine impermeable clay, and this, well tamped, is also used for the beds of the pans. Nearly 600 wells have been sunk in the works. The first 4 feet of the strata passed through consist usually of sandy loam with thin bands of clay; below this, to at least 15 feet, is a clayey loam. Brine in a well may be met with at a depth of anything from 1½ to 17 feet, the variation corresponding roughly with its distance from a trench. It is raised by means of a tub, suspended by a rope from a bamboo pole pivoted 3 feet from the ground, and is run directly into the crystallising pans to a depth of about 3 inches. Sometimes the "lunari" replenishes his pans three or four times, sometimes he is content with the salt crop derived from one filling. When the crop is ready, the mother liquor is run off on to the neighbouring ground. The salt crystals are scraped from the floor of the pan with wooden scrapers, washed with brine from a well, accumulated in small heaps and, after passing inspection, stored in large heaps in the open.

Function of the trenches.

The trenches are not a mere accessory to the construction of the protecting embankment. Being filled at spring tide every fortnight, they act to some extent as a supply reservoir and, by keeping up the hydraulic head, increase the flow of brine in the wells. At the time of my visit (August, 1924) the concentration in the trenches varied between 8° and 13·5° Baumé—that of sea water at the shore was 3° Baumé—so that they serve as useful condensers, subsidiary to the normal sea water seepage

With a climate such as that of Maurypur seepage of fresh water from the low hills on the landward side is negligible; all the seepage is from the sea.

Proposed increased production.

The purpose of my visit was to advise on a proposed increase in production. For several years the works have been producing from 11,000 tons to 16,000 tons of salt per annum. Three private companies proposed to lease from Government about 1,600 acres in neighbouring areas, increasing the production to 200,000 tons per annum, and the Commissioner in Sind wished to know if the resources available could maintain this.

On new sites outside the present works practically saturated brine is found to a depth of about 6 feet, and below this less concentrated brine is said to be found. If we assume a porosity of 25 per cent for the upper 6 feet of soil, we might expect from the brine already *in situ* an immediate output of the order of 1,000 tons per acre. Such an output, however, could not be kept up. The concentration of the brine would gradually diminish, until it reached a condition of equilibrium dependent on many factors such as distance from seepage supply and rates of flow, evaporation and removal. Although it is not possible to calculate the resultant of these factors, we do have some evidence of their ultimate effect. One half of the works has been running for only a few years, but the other 90 acres have been producing since 1878. During these 46 years their average annual output has been 109 tons per acre, and the production shows no signs of falling off. We may assume that a condition of equilibrium between production and brine supply from the sea has been reached in these old works, and that, with similar conditions, like areas would be permanently capable of producing the same amount. For a supply of 200,000 tons of salt per annum each of the 1,800 acres would have to produce 111 tons. There seems to be no reason to doubt their capacity, for the beach is remarkably regular throughout this area. In the new ground this figure might be far exceeded for several years, but, if the removal of the concentrated brine were too rapid, production might be seriously curtailed.

Suggested changes.

It appears to me that with such favourable climatic and tidal conditions the question of evaporation direct from sea water through condensers should be considered, for the expense of the necessary earthworks would probably be much less than that involved in sinking the huge number of wells required under the present system. South and south-west of the present works, too, is a large, shallow backwater, connected by a narrow creek to Karachi harbour. It is from the tidal overflow of this backwater that the salt works are periodically supplied. If a dam were built across the narrow part of the creek, the backwater might be used as a reservoir for the condensers and might even be used as a preliminary condenser itself.

Whatever method of salt recovery may be used, an effort should be made to get rid of the present pernicious system of allowing all mother liquors to remain in the area of manufacture.

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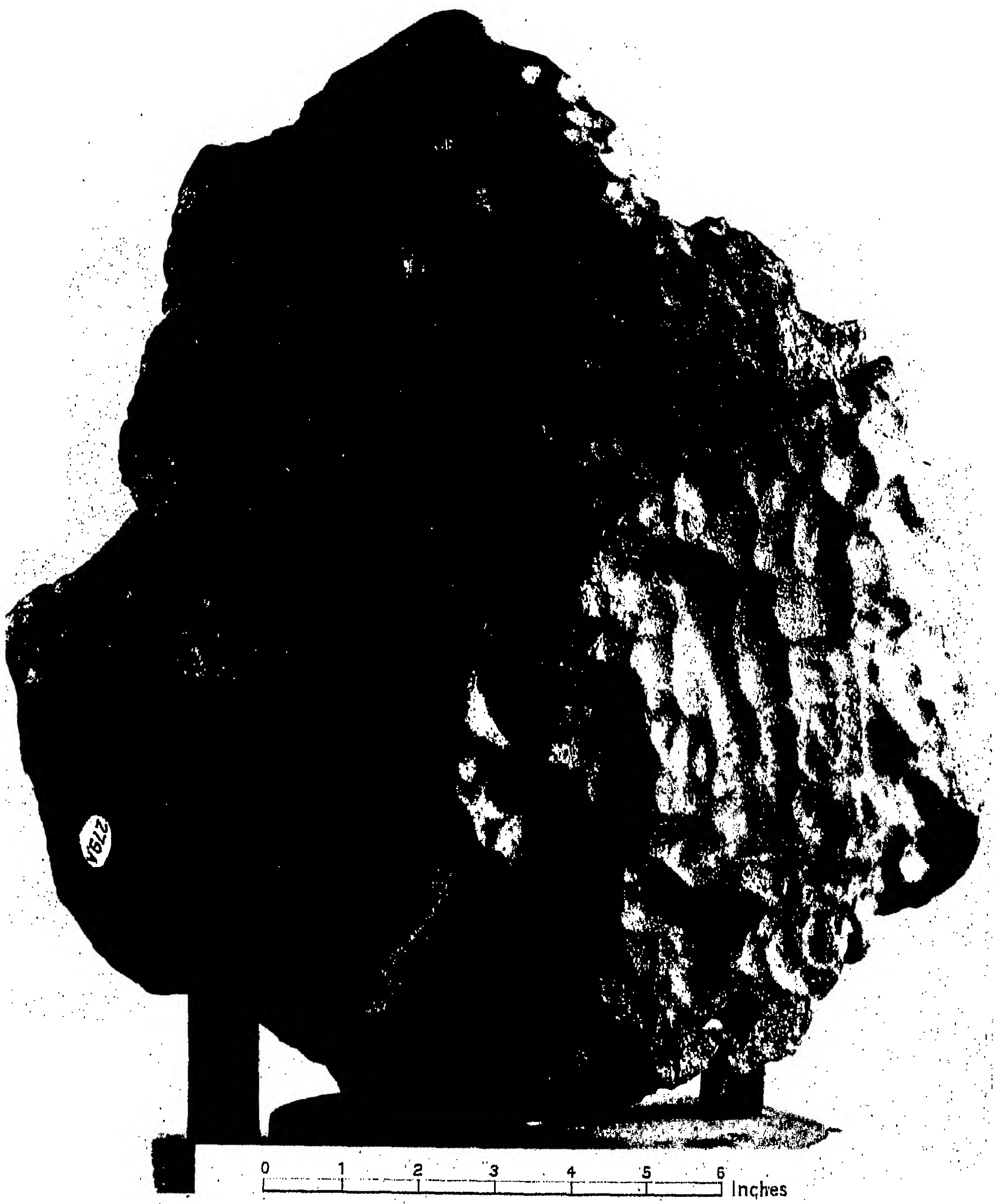

H. Walker & K. F. Watkinson, Photo. *G. S. I. Calcutta.*

THE MERUA METEORITE—PORTION A.

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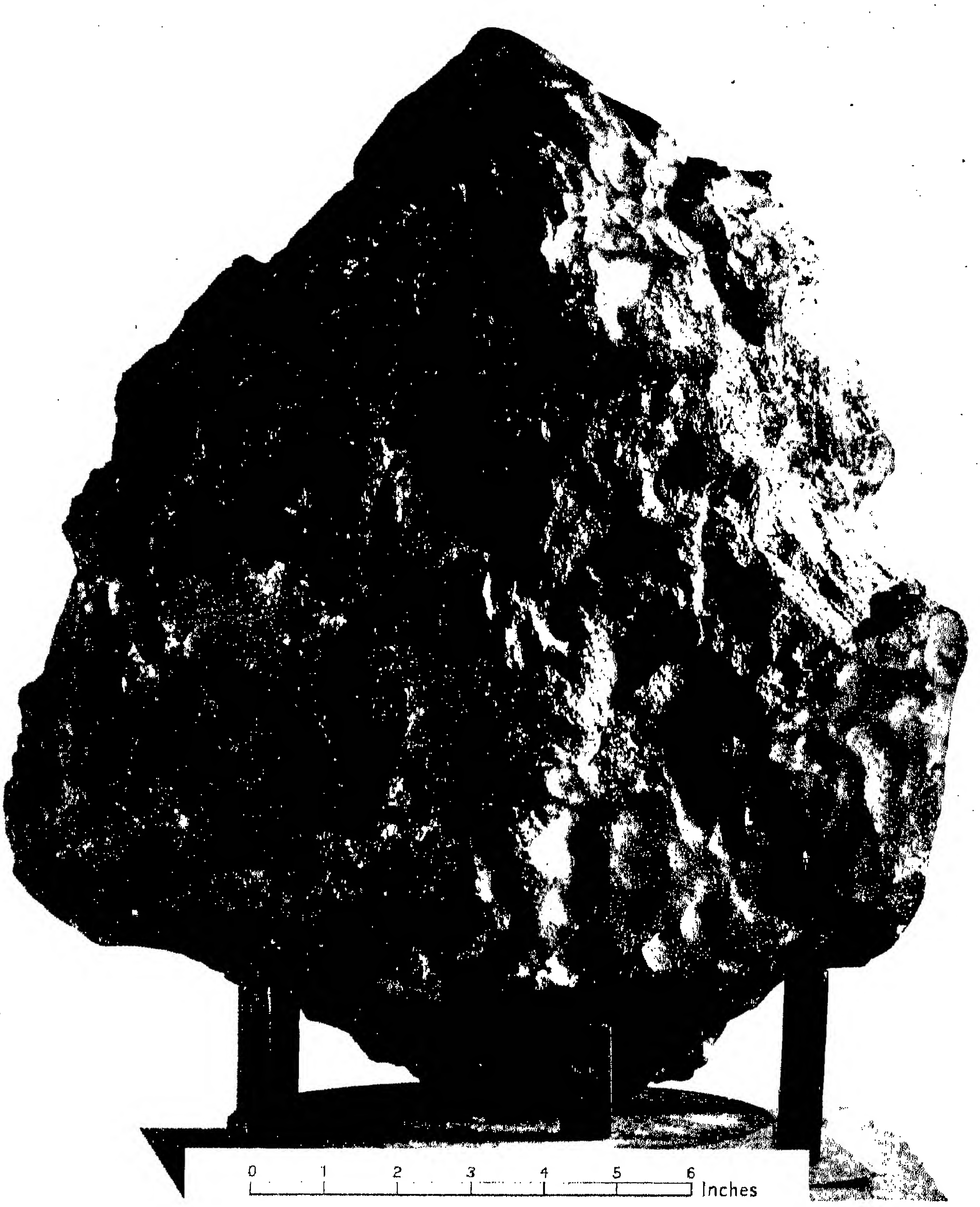
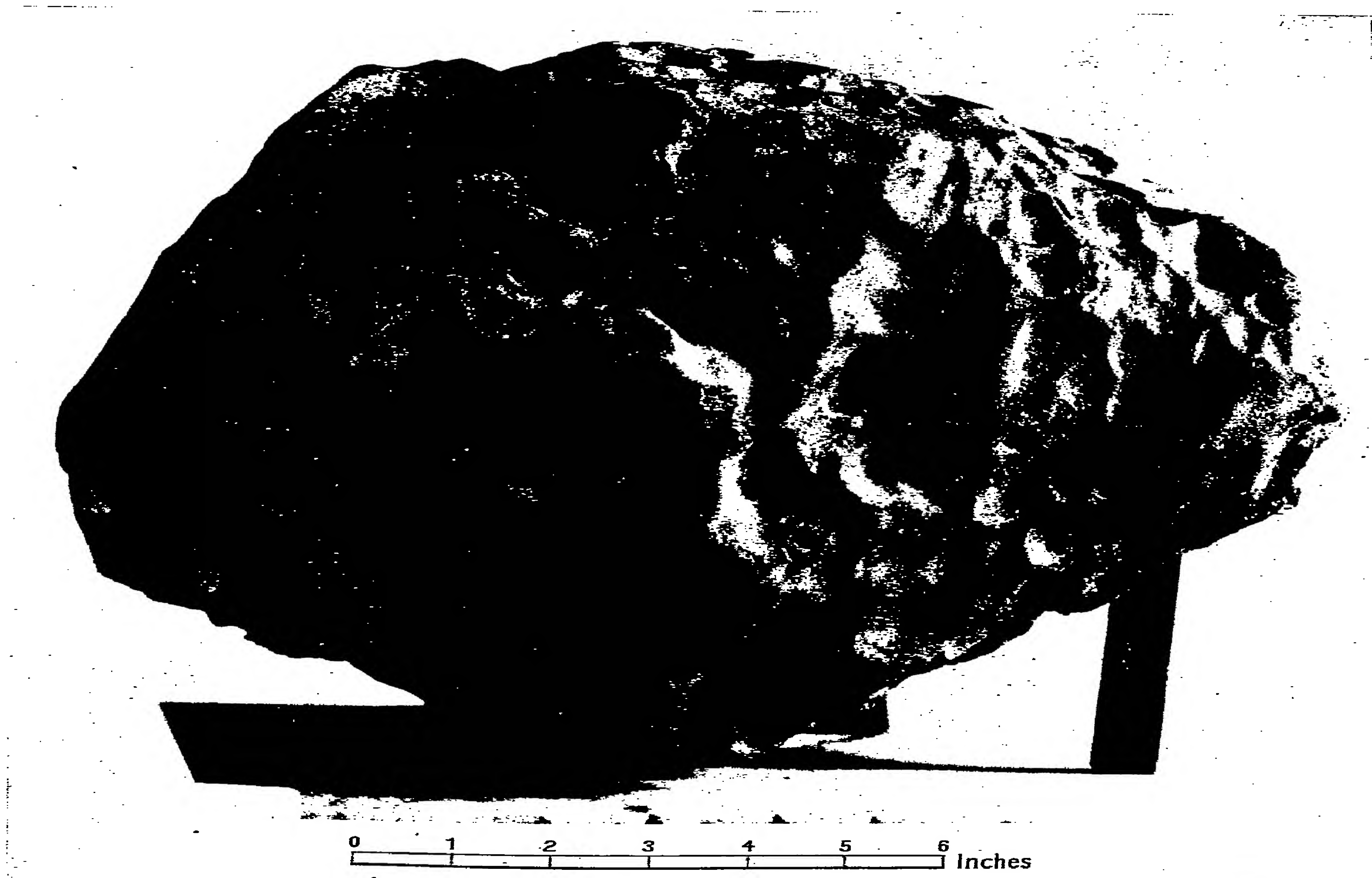


H. Walker & K. F. Watkinson, Photo. G. S. I. Calcutta.

THE MERUA METEORITE—PORTION A.

H. Walker & K. F. Watkinson. Photo. *G. S. I. Calcutta.*

THE MERUA METEORITE—PORTION A.



H. Walker & K. F. Watkinson, Photo. *G. S. I. Calcutta.*

THE MERUA METEORITE—PORTION A.

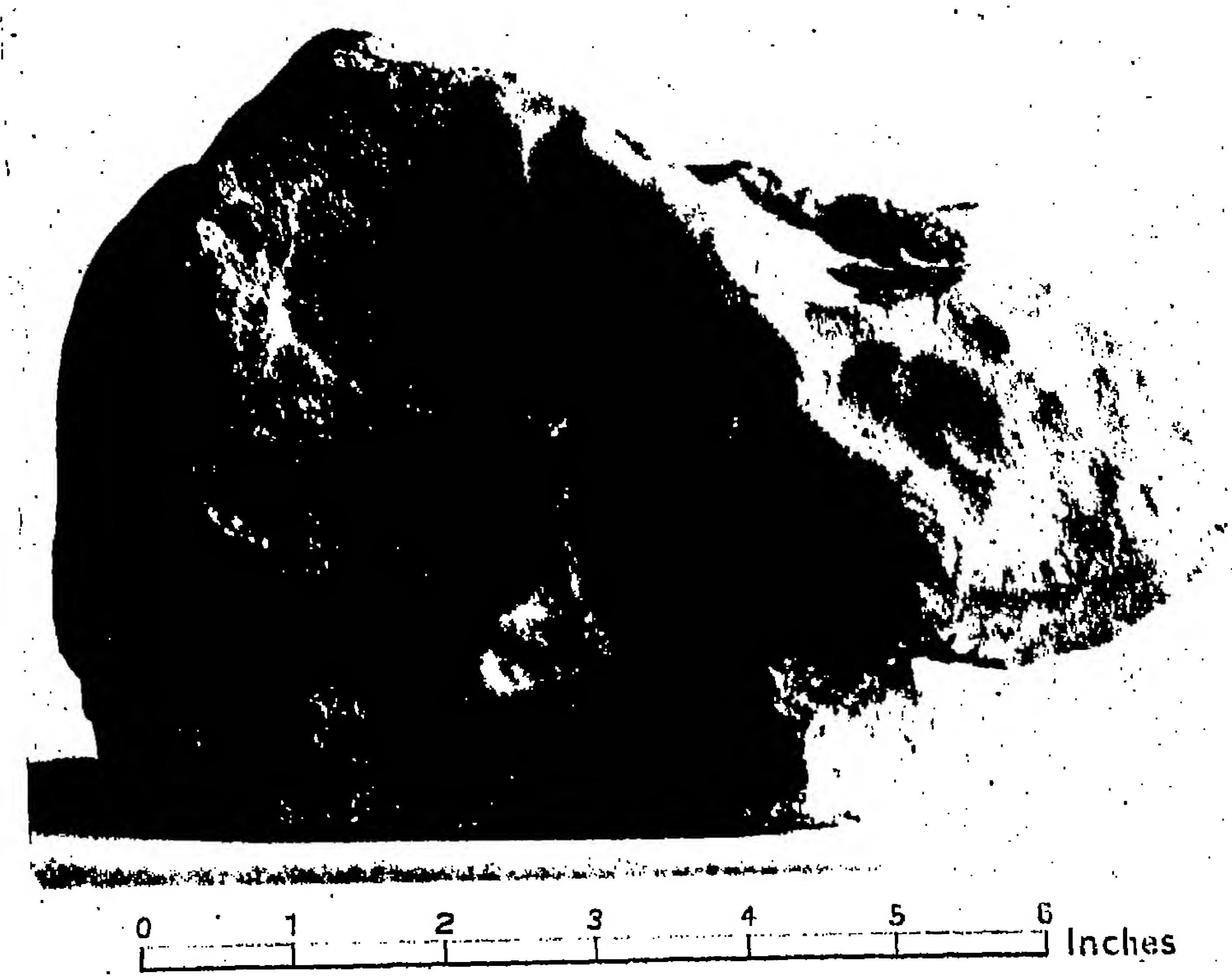


FIG. 1.

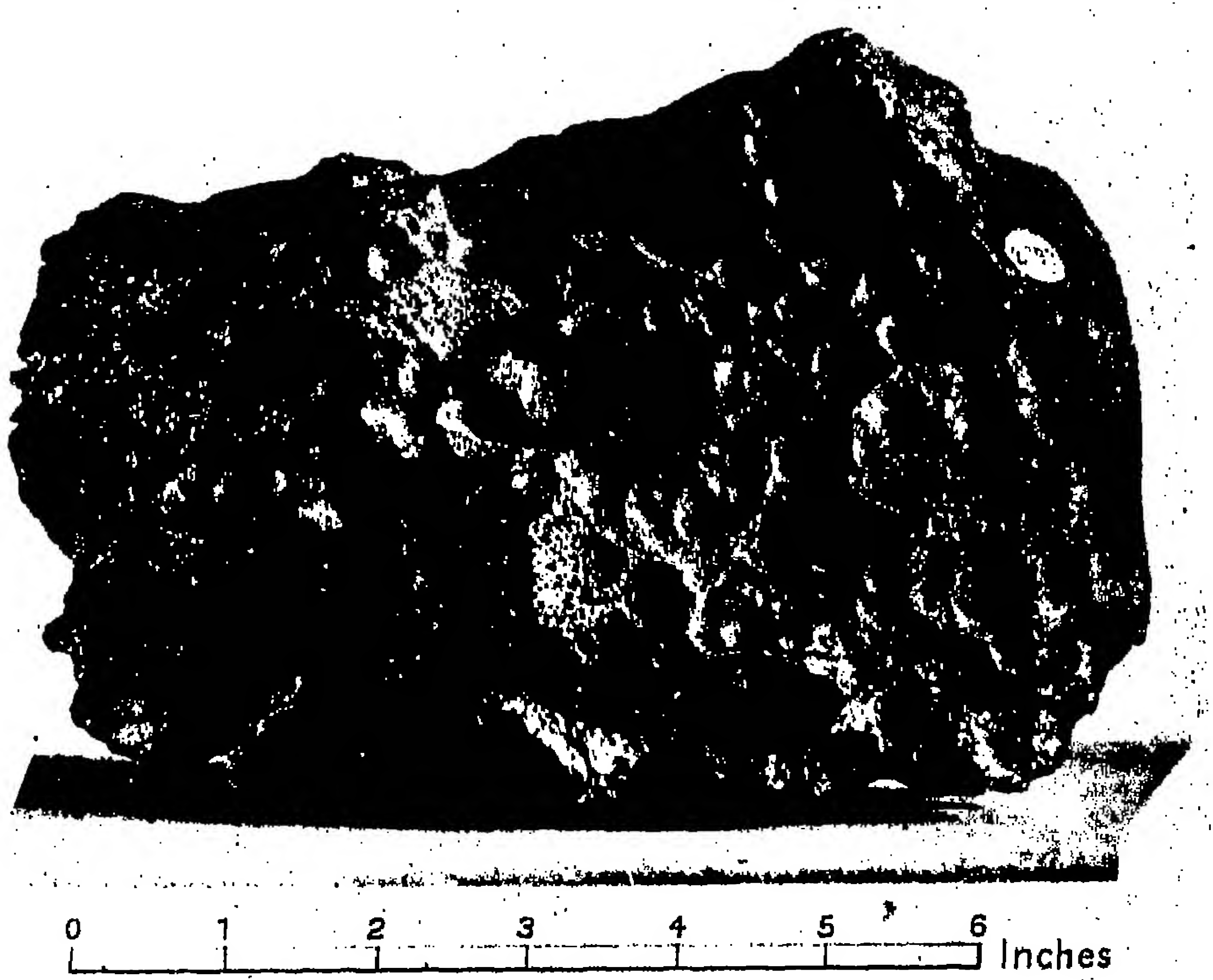


FIG. 2.

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THE MERUA METEORITE.—PORTION B.

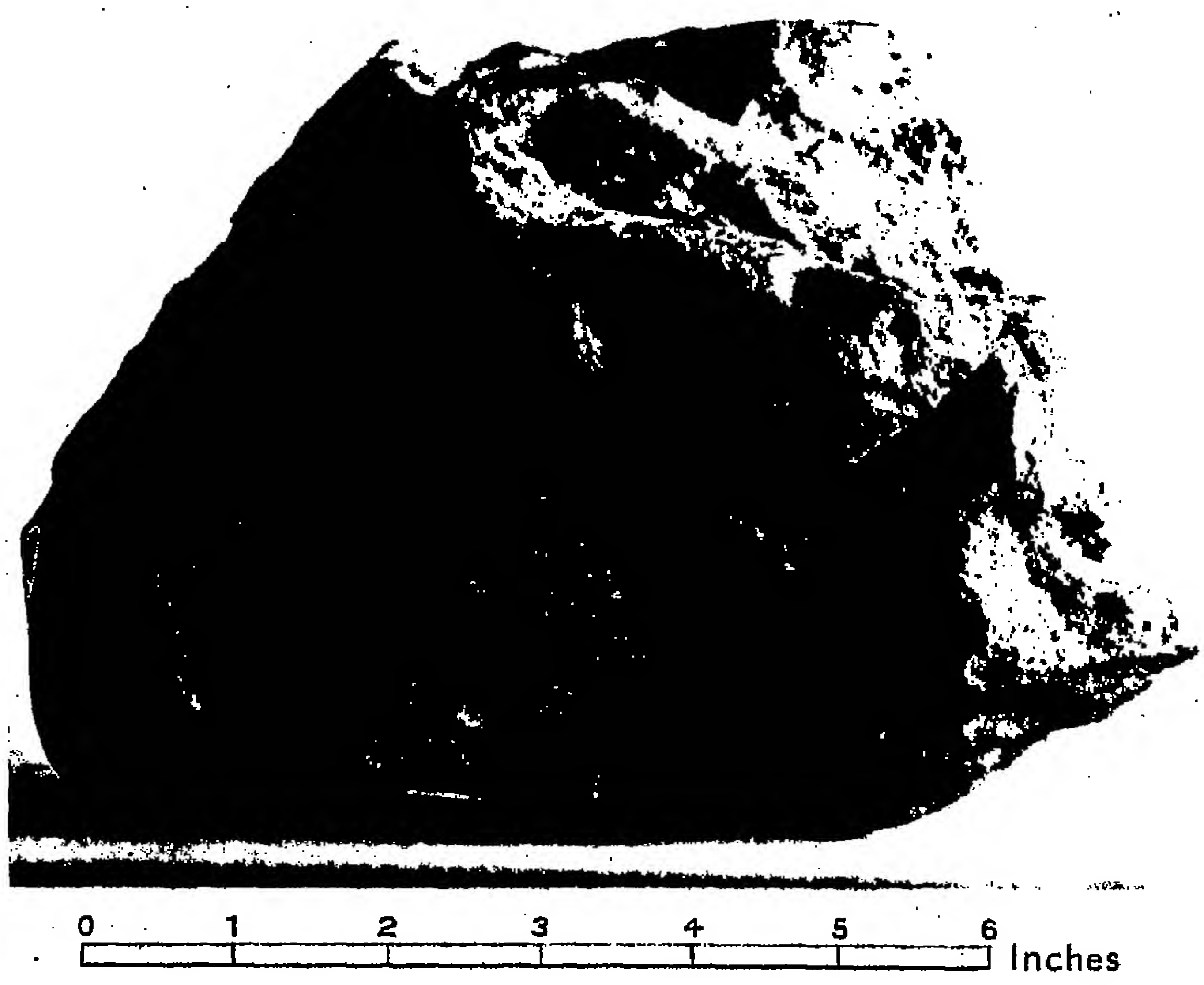

FIG. 1.

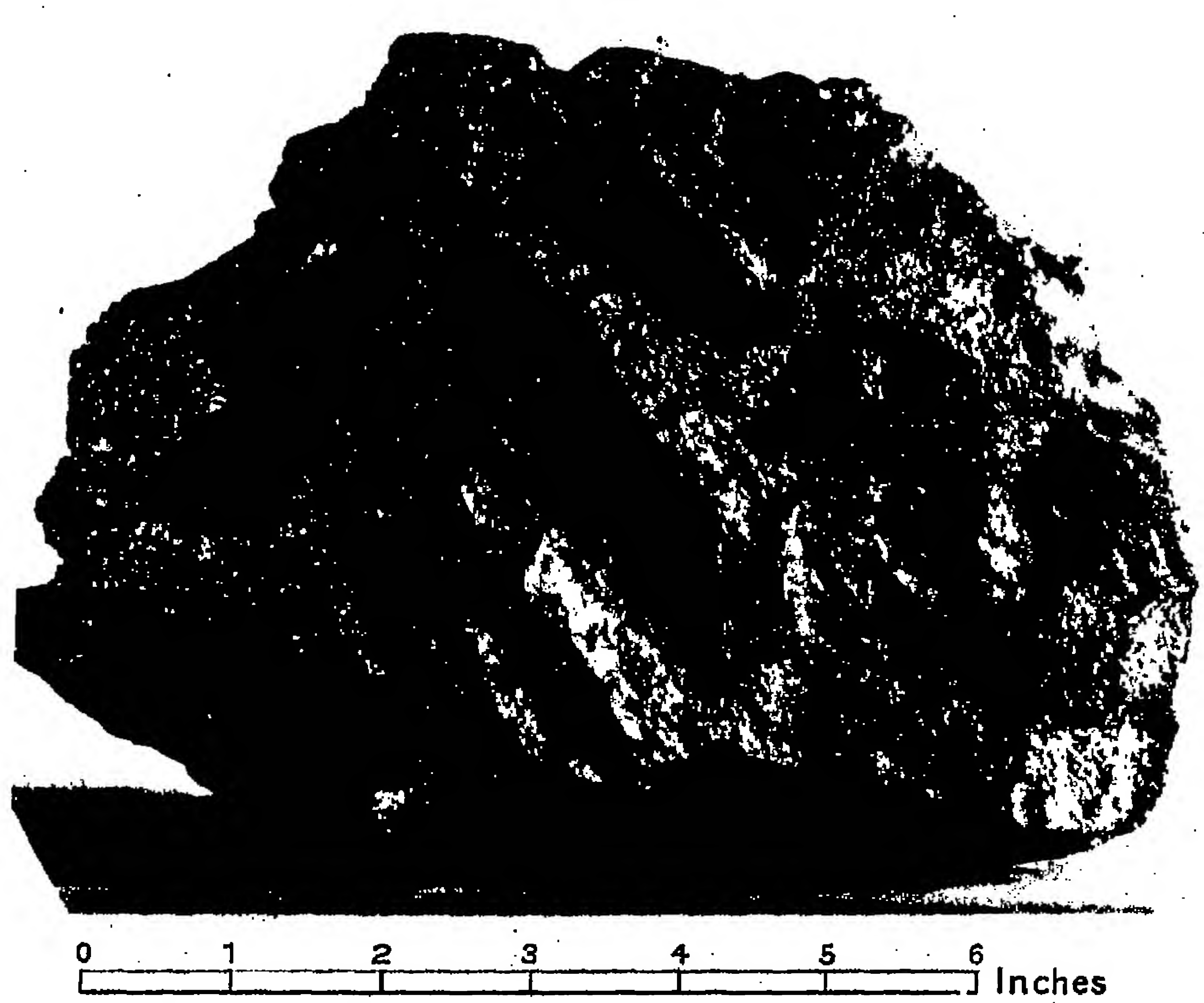

FIG. 2.

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THE MERUA METEORITE.—PORTION B.

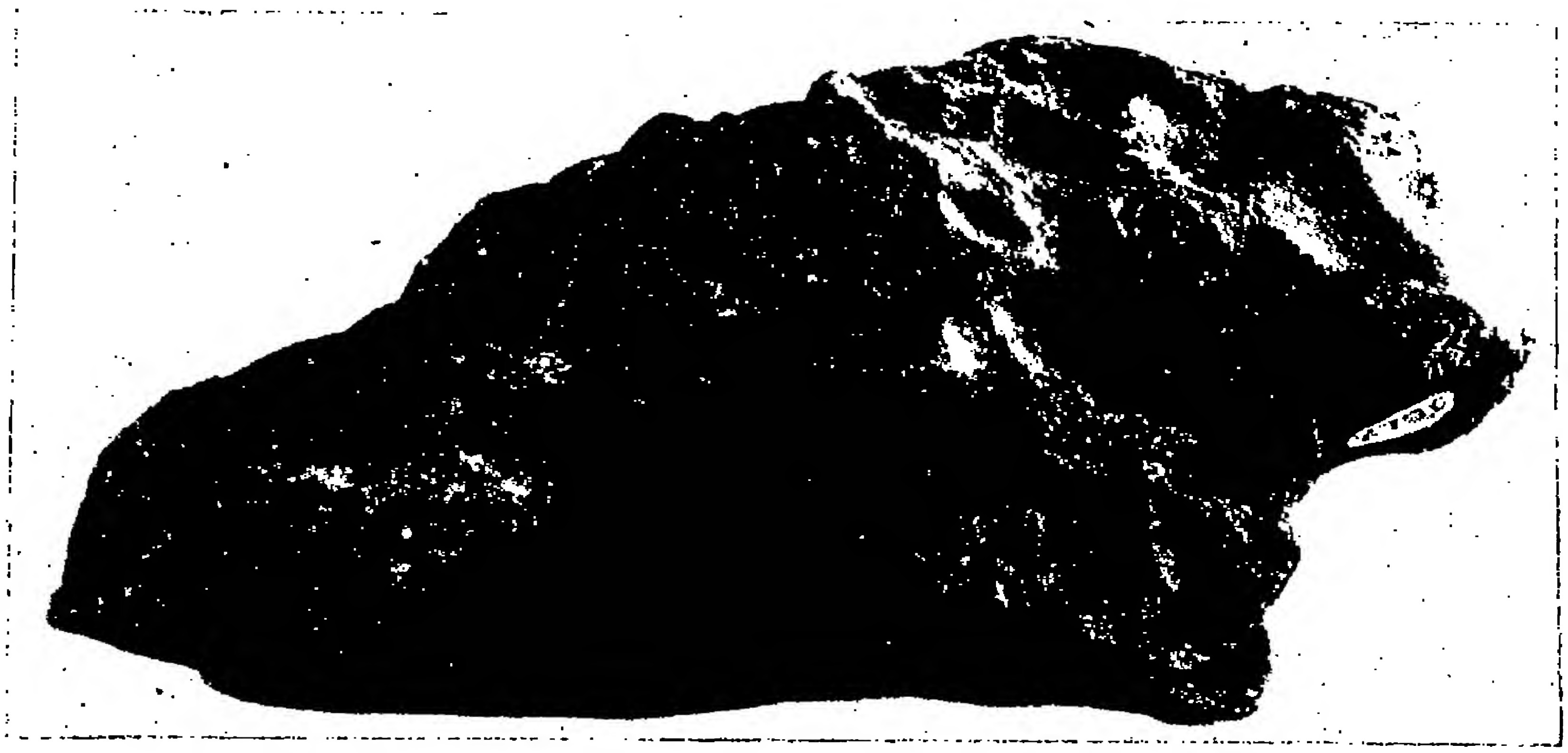

Fig. 1.

Fig. 2.

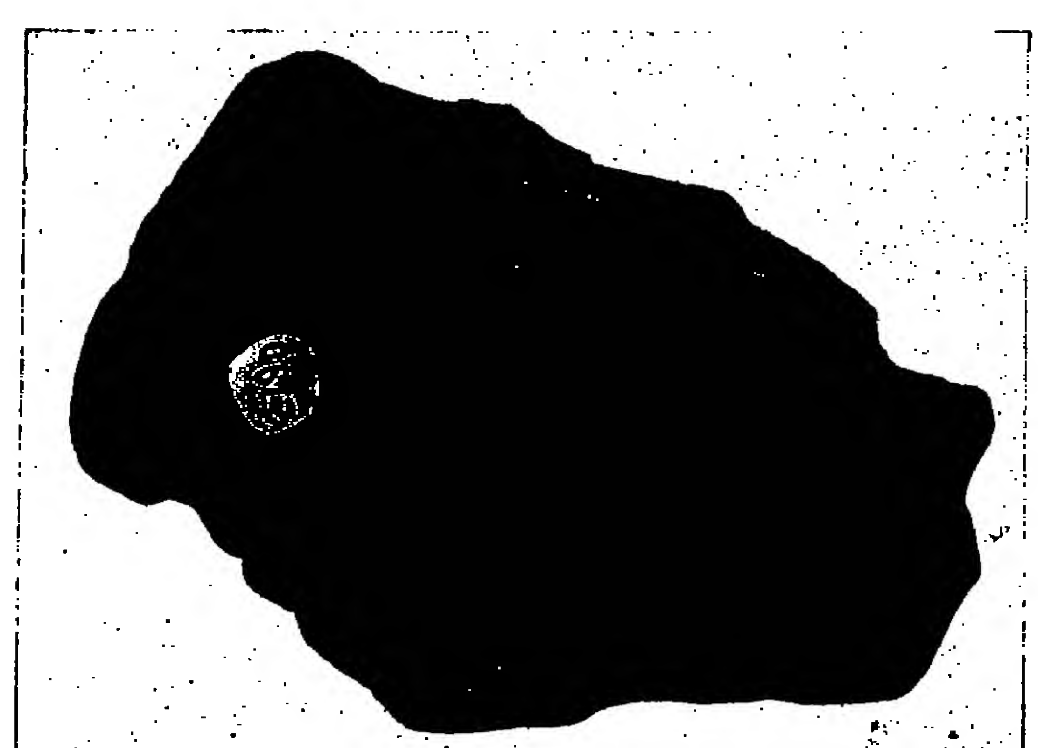

Fig. 3.

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THE MERUA METEORITE—FIGS. 1 & 2. PORTION C. FIG. 3. PORTION D.

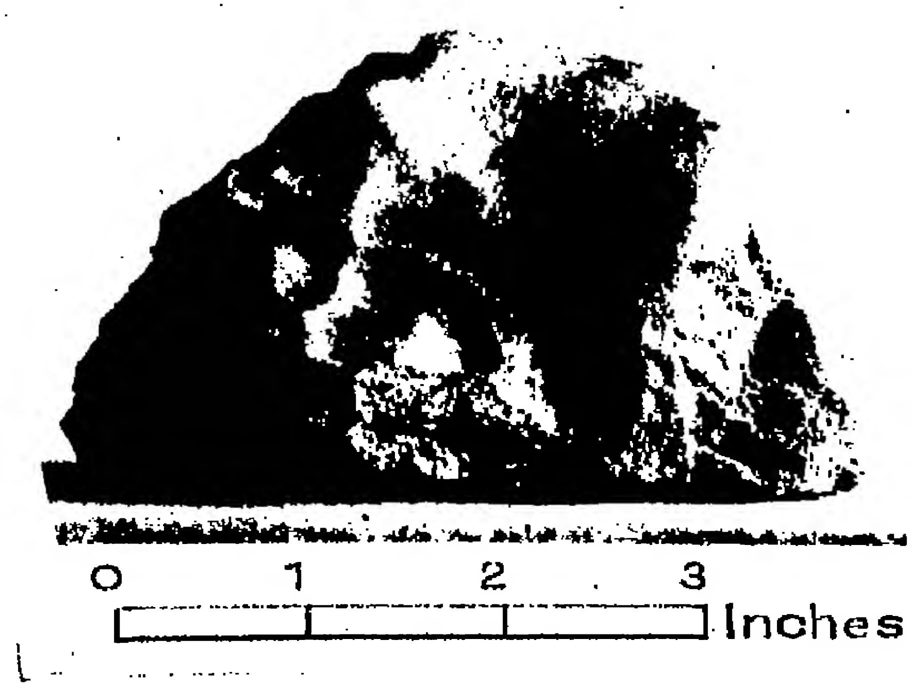


Fig. 1.

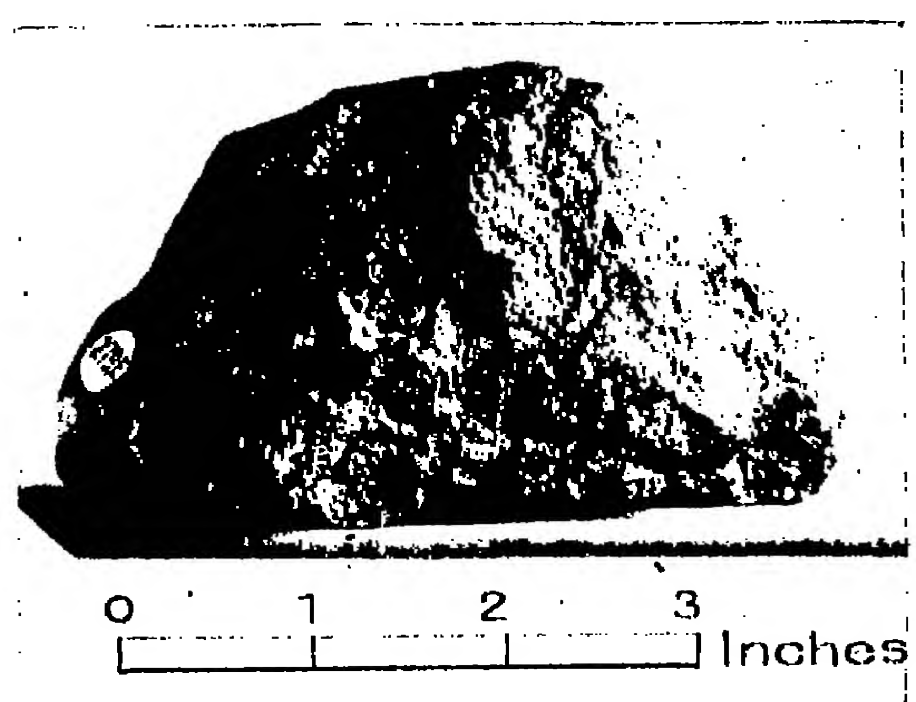


Fig. 2.

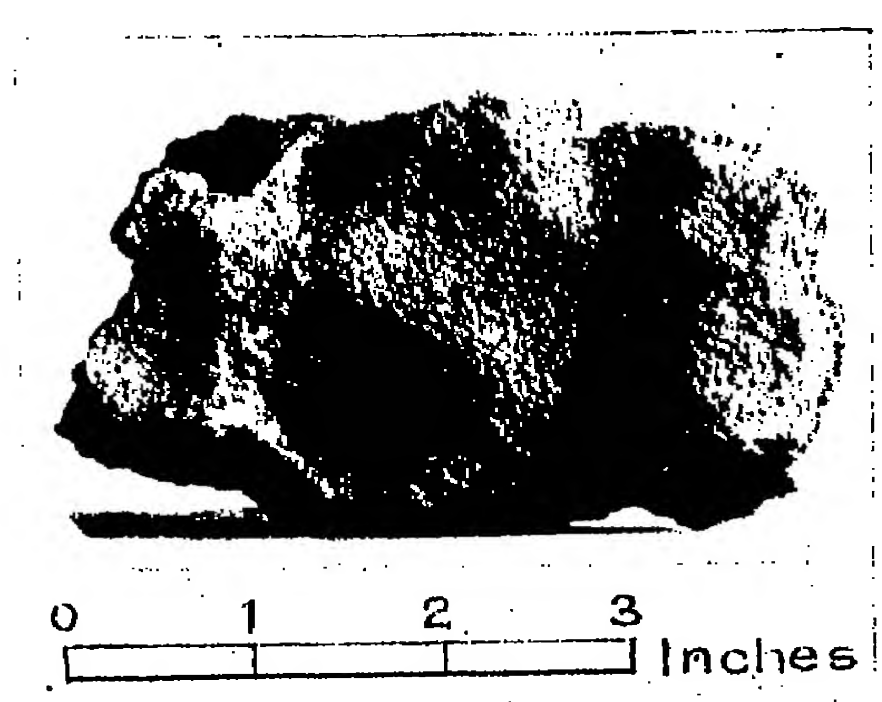


Fig. 3.

H. Walker & K. F. Watkinson, Photos. *G. S. I. Calcutta.*

THE MERUA METEORITE—PORTION E.

Fig. 1. × 20.

Fig. 2. × 20.

Fig. 3. × 20.

H. Walker & T. C. Chowdhury, Photomicros. *G. S. I. Calcutta.*

THE MERUA METEORITE—PORTION E.

Records, Vol. LVI, Pl. 28.

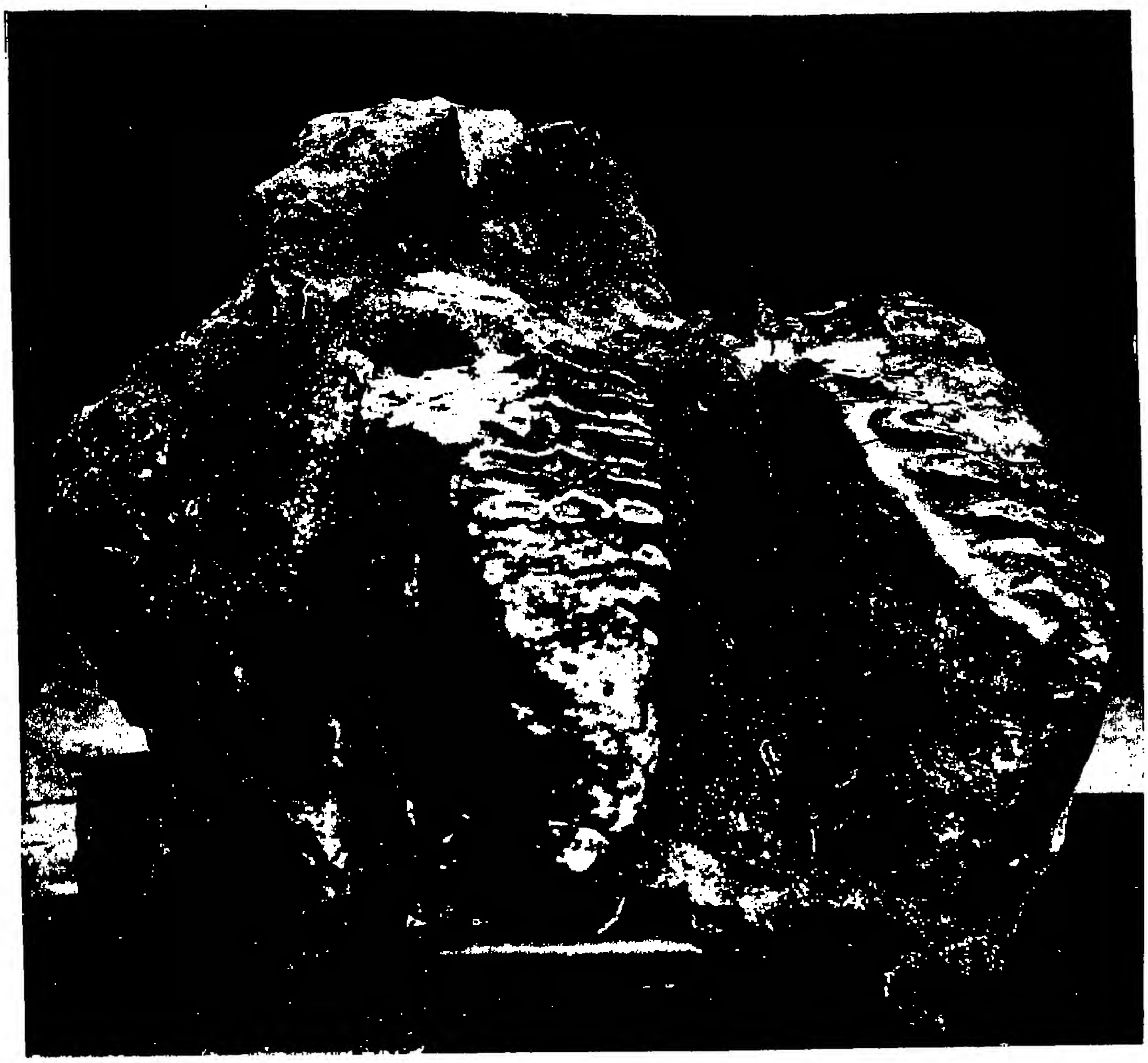
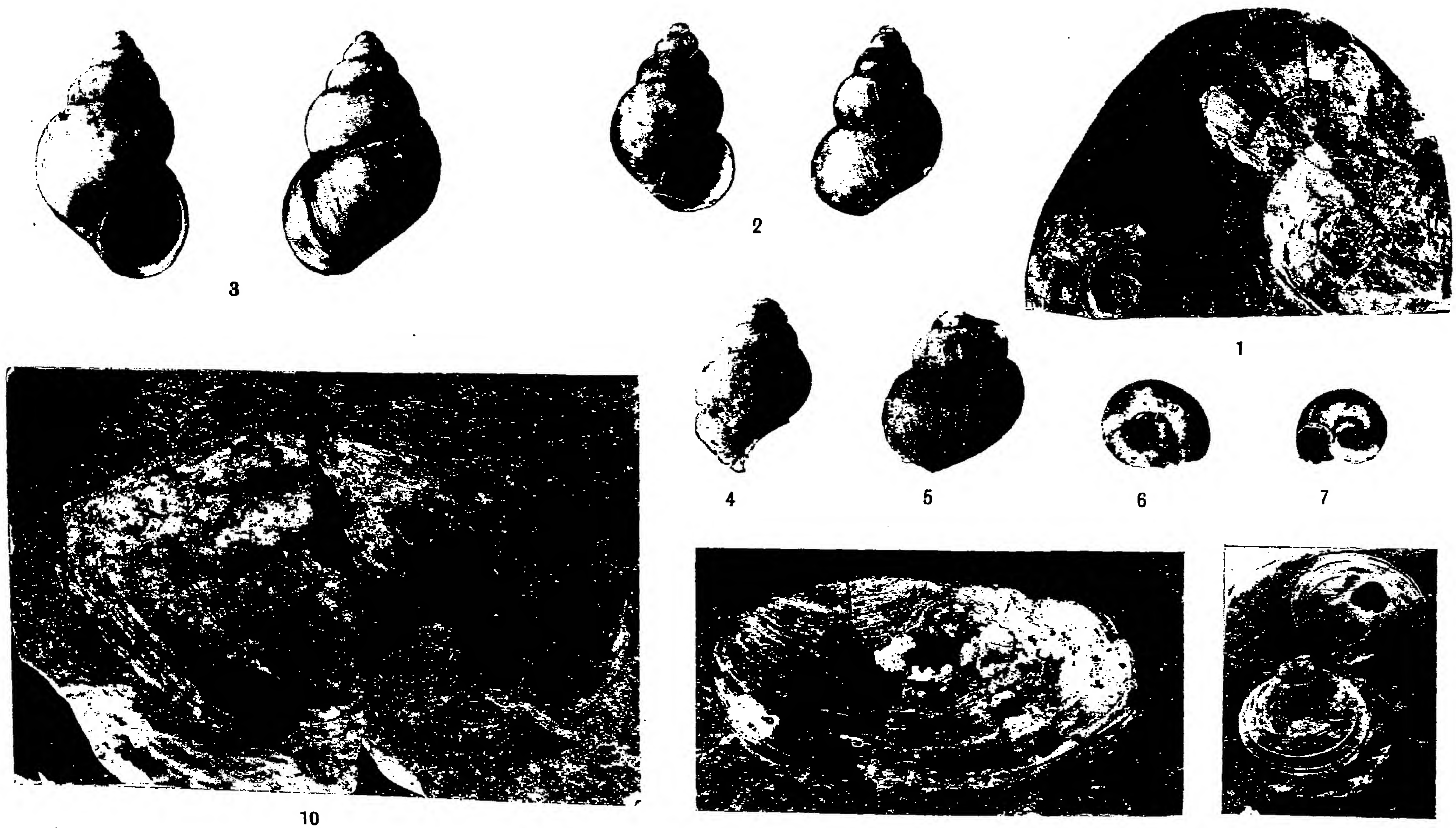


FIG. 1. THE TWO UPPER MOLARS *M3* IMPLANTED IN THE PALATINE. (*$\frac{2}{9}$ Natural size.*)

D. N. Wadia, Photos. *G. S. I. Calcutta.*

FIG. 2. THE TUSK AS VIEWED OBLIQUELY. (*$\frac{1}{35}$ Natural size.*)

Records, Vol. LVI, Pl. 29.



B. Prashad, Photos.

FRESH WATER FOSSIL MOLLUSCS FROM KAREWAS OF KASHMIR.

G. S. I. Calcutta.